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*The Journal of*
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VOL. 10, No. 3 SEPTEMBER, 1944

# Some Aspects of Plant Pathology in Western Australia*

By
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## Historical.

Since the earliest days of settlement in Western Australia, the small population which sought to develop such a huge territory encountered many difficulties. Floods, bush fires and droughts occurred all too frequently and agricultural progress, especially during the last century, was only made possible by the dogged perseverance of the pioneer settlers. Records are not lacking which show that during this era plant diseases at times developed seriously and added to the many difficulties impeding agricultural development.

In 1868 the wheat crop in the Victoria district, adjacent to Geraldton, amounting to some 14,000 acres, proved an almost total failure owing to the rust.[8] Also, a few years later, we learn that a number of small vineyards in Western Australia were rooted out or allowed to run wild, on account of the powdery mildew disease which at that time was little understood.[2] To clarify this latter remark it should be borne in mind that plant pathology as a branch of applied science was then only in its infancy.

The causal relationship of fungal pathogens to such important diseases as rusts, smuts, powdery mildew and potato blight was only demonstrated from 1850-1865 by the brilliant scientists Anton de Bary and the Tulasne brothers; bacteria were not shown to be a cause of disease in plants until 1877, when Burrill in America published his epoch-making paper on fire blight of apples and pears; and Bordeaux mixture, the most widely used fungicide today, was not discovered until 1882. These and other discoveries stimulated increasing interest in the young science of plant pathology, but as happens even today, the dissemination and application of scientific knowledge to practice was very tardy.

The year 1880 is notable for the passing of the "Destructive Insects and Substances Act", the first legislation in the colony of Western Australia designed to prevent the introduction of diseases and pests. Regulations under this Act were gazetted from time to time and one of these regulations prohibited the importation into the colony of apples and pears to prevent the introduction of the dreaded codlin moth. Unwittingly, perhaps, this action also safeguarded us from the dreaded apple scab disease, which, together with codlin moth, was widespread even at that time in the eastern colonies of Australia.

* Presidential address to the Western Australian Branch of the Institute, 23rd June, 1944.

In 1894 the Bureau of Agriculture (the forerunner of the present day Department of Agriculture) was founded. It was in charge of a secretary, Lindley Cowan, and controlled by a board of management with Mr. Charles Harper, M.L.A., as chairman. Within a few months of its foundation, the Bureau framed certain new regulations under the " Destructive Insects and Substances Act ", 1880, which were gazetted. These became known as " The Disinfecting Regulations " and they were anything but popular at the time. They were modelled on similar regulations in force in California and they provided for the compulsory examination of introduced plant material at ports of entry south of Champion Bay. They also provided for the destruction of all such material infested with pests or disease germs likely to be injurious to commercial growers, and for the compulsory disinfection of all visibly healthy material.[7]

In explaining the necessity for its action, the Bureau stated: " Happily for our fruit growers many of the insects and diseases which have occasioned enormous losses to growers in the neighbouring colonies are so far as is known not here yet and it is in the hope of preventing their coming here that the Bureau framed the present regulations." We should be everlastingly grateful to those who introduced this legislation, for undoubtedly our freedom from certain major diseases today, can be traced very largely to their wisdom and foresight.

A fortnightly journal of agriculture was also issued by the Bureau and numerous references to plant diseases appear even in the earliest volumes. In general, they were descriptive accounts of diseases, many of which have never been recorded here, quoted from the works of various pathologists of the day, including Tryon of Queensland, Cobb of New South Wales, and McAlpine of Victoria.

The first local treatise on plant diseases is contained in the *Hand Book of Horticulture and Viticulture*, published in 1895 by the Bureau. It was compiled by Mr. A. Despeissis, the Bureau's horticultural expert, and it dealt almost entirely with the diseases of fruit trees. Judging from the numerous citations, its production was considerably aided by the researches of Daniel McAlpine in Victoria, who has aptly been described as the father of plant pathology in Australia. Again, many diseases are described which do not occur here, but nevertheless, considering the times, it was a most valuable contribution and even today later editions of this work are still in use by some horticulturalists.

In 1896, Mr. R. Helms was appointed biologist of the Bureau, in which position he remained until 1900. He was mainly concerned with insect pests, but it is noteworthy that take-all and ear cockle of wheat were recorded by him.

From 1900 until 1911, the State was very largely dependent on help in plant pathological matters from outside sources, mainly Victoria and New South Wales. In the absence of a local pathologist, frequent arguments, many of them rather acrimonious, took place during this period, concerning the nature and causation of various diseases. For example, in the spring of 1909 an epidemic of the dreaded Irish Blight potato disease occurred in all States of the Commonwealth.[6] In Western Australia it became widespread in the Coogee, Guildford and Maddington districts. Incidentally, this is the first authentic record of the disease and it was made by the late Mr. L. J. Newman, who many of us knew so well. Professor Lowrie, at that time Director of Agriculture, immediately took strong action and quarantined the area within a 30-mile radius of Perth in order to prevent the spread of the disease southward. Drastic restrictive measures were also passed to prevent the importation of diseased tubers from Victoria, by which means its introduction was suspected. The measures required that all potatoes imported from Victoria, Tasmania and New South Wales be accompanied by a government certificate stating that they had been grown at least 50 miles from any district known to have—or to have had—Irish blight. Compliance with these conditions so restricted imports that consumers were short supplied, prices rose, and the whole matter became a burning question for many months.

The accuracy of the disease diagnosis was openly questioned and officers of the Department of Agriculture were severely castigated through the columns of the press. Even in the face of such strong public opinion, however, the Department would not repeal the regulations, explaining that " if we intend to grow within the State sufficient potatoes for local requirements, it is imperative that we should keep our fields clean ". Who can doubt that this courageous and resolute action became traditional in the Department and had far-reaching effects on future policy ?

The epidemic of Irish blight had another good effect : it drew attention to the need for a competent pathologist within the State, and in January, 1911, Dr. F. Stoward was appointed Botanist and Vegetable Pathologist. Stoward's appointment was thus an epoch-making one in the State realm of plant pathology. He was the first worker to be definitely classified as vegetable pathologist, and he was the first man with high scientific attainments to hold this or a similar position. One of Stoward's first duties was to confirm the identification of Irish blight and make an authoritative statement on the disease. This did much to allay public doubts and reconcile public opinion to the Department's past actions.

Stoward's approach to the many disease problems of the day was revolutionary. His work was marked by the care and caution of the true scientist, and naturally, considering the times, he was rather a disappointment to those who considered ready and dogmatic advice the hallmark of the expert. Stoward's services were made full use of by other departmental branches, and during his time the cooperative approach to problems of mutual interest became firmly established.

With Mr. G. L. Sutton, then Commissioner of the Wheat Belt, Stoward did good work on the wheat diseases, Septoria and covered smut or bunt, which at that time were extremely serious. Septoria was shown to be largely a disease of wheat heading out of season, due to very early sowing—a customary and necessary practice with the old late maturing wheats, but one fraught with risk when applied to the new, early maturing wheats then being released. Established custom, however, proved difficult to alter, and the solution of the Septoria problem lay very largely, therefore, in extension work.

Similarly with wheat smut ; farmers had so many theories as to its cause that they were only persuaded with great difficulty that the disease was readily controllable by bluestone pickling. A vigorous extension campaign conducted in the wheat belt gradually won farmers over to better methods, and in achieving this the wheat experiment farms did work of outstanding value. It is fitting at this stage to mention that but for Sutton's efforts these same farms would have been abandoned in 1911 on Professor Lowrie's recommendation that they had outlived their usefulness. When Stoward resigned in 1917, the Septoria and wheat smut diseases were of much less consequence, and the farmers' confidence in technical advice from the Agricultural Department was greatly improved.

From 1918 to 1921, D. A. Herbert, a Melbourne graduate, filled the position of Botanist and Plant Pathologist, and during his term of office Herbert was attached to the Mines Department with the Government Analyst, Mr. E. H. Mann, as his immediate chief. The reasons given for this change—better laboratory facilities—hardly justified such a retrograde step. Judging from annual reports, Herbert was largely occupied with botanical rather than pathological work, but he also interested himself in the non-parasitic diseases of fruit trees and certain higher plant parasites. His publication " The Crushed Cell Theory of Bitter Pit of Apples ", and his demonstration of the root parasitism of the Christmas tree (*Nuytsia floribunda*) brought him wide recognition.

Herbert was succeeded by W. M. Carne, and at the instigation of the newly appointed Director of Agriculture, Mr. G. L. Sutton, the Branch was brought once more under the control of the Department of Agriculture. This restored the cooperation between branches which, during Herbert's time, had declined. With

the appointment of Carne as Economic Botanist and Plant Pathologist and lecturer in these subjects at the University of Western Australia, a new era commenced in 1923.

Carne, whose interests were mainly pathological, had wide and lengthy experience, gained while attached to the New South Wales Department of Agriculture. Under his leadership, public interest in plant pathological matters was greatly stimulated. The revival of the *Agricultural Journal* in 1923, after a lapse of some fifteen years, helped him to achieve this, and many articles appeared subsequently from his pen. From the outset, Carne engaged in research work, and had many notable successes, but when he resigned in 1928 to become Senior Pathologist with the Council for Scientific and Industrial Research the routine advisory and extension work had increased so much that opportunities for research were very limited. For this reason Carne recommended the division of Botany and Plant Pathology into separate branches, and his recommendation was adopted. Carne is best remembered for his work on bitter pit and other non-parasitic diseases of apples, in conjunction with Pittman and Elliot, and for his investigations on brown rot of citrus.

Under H. A. Pittman, who succeeded Carne as Plant Pathologist in 1929, advisory and extension work to growers increased enormously. He also developed and popularized leguminous seed inoculation and with the former Superintendent of Horticulture, his work on apple scab eradication proved of immense value to the State. Pittman was a prolific writer, and during his nine years of office he was responsible for some forty publications in the journal of the Department of Agriculture. He also became noted for his teaching ability and for his ready cooperation, and when he resigned in 1938 to become Principal of Dookie Agricultural College, his loss was felt keenly by colleagues and primary producers alike.

## Contributions to Agricultural Progress.

It is now just a little over thirty-three years since plant pathology was first practised in Western Australia by a worker trained in this branch of science. During that time much has been accomplished and a number of diseases formerly very troublesome are now of much less consequence.

Some of these contributions to agricultural progress in Western Australia have already been noticed, and others worthy of mention have been concerned with citrus water spot, flag smut of wheat, storage disease of potatoes, and the degeneration of the Delaware potato variety.

*Flag Smut.*—The conquest of flag smut is of especial interest because it illustrates very aptly the valuable help that the farmer can give at times in the elucidation of his own problems. Flag smut of wheat was officially recorded in Western Australia in 1922, though its first occurrence was subsequently traced back some years earlier. It was almost certainly introduced with wheat imported from the eastern States, and probably New South Wales, where even in 1922 the disease was fairly widespread and on the increase.

By 1923 it was realized that Flag Smut was rapidly spreading here also. Carne, recognizing its seriousness, issued a press paragraph in September of that year, asking farmers to forward specimens of this new disease together with observations as to its distribution. Within a week a reply was received from Mr. J. C. Perry of Belka, stating " Three years ago, after taking over this farm, I planted 175 acres of fallow, half with Gluyas Early and half with Nabawa, but flag smut was found only in the Gluyas Early. Next year the same paddock was planted with Nabawa, and flag smut was unnoticeable. This year, Gluyas again appears to be most susceptible ". Mr. Perry also remarked that many other farmers were suffering considerable losses, but were ignorant of the fact as they had no idea of the existence of flag smut.

These very valuable observations provided the first clue to the varietal resistance of Nabawa. They were followed up and quickly confirmed by field surveys and by

pot experiments carried out by Carne. The early recognition of Nabawa's flag smut resistance proved an outstanding event in the history of Australian wheat production. At this time no other commercially desirable wheats possessing resistance were known in Australia ; and in New South Wales attempts were even being made to breed resistant varieties by crossing with certain hard red wheats imported from America.[4]

In New South Wales and Victoria, especially, flag smut was so widespread that losses of 10 per cent. were common,[1] and Noble, at about the same time, estimated that the average yearly loss from flag smut throughout the Commonwealth was 3 per cent. In Western Australia, Carne estimated that our losses in 1924 were still probably under a bushel to the acre, but he pointed out that even a loss of half a bushel to the acre would approximate to 800,000 bushels on our 1923 production.

Largely, then, because of its flag smut resistance, the variety Nabawa, which was sown on a negligible acreage in 1925, became in seven years, the most popular Australian wheat, being sown on 32 per cent. of the five million acres.[5]

But for Carne's initiative and a farmer's cooperation, the discovery of this varietal characteristic might easily have been delayed for some years, with serious wastage in Australian wheat production. Nabawa has since been widely used as a resistant parent and for many years now, high resistance to flag smut, in addition to other qualities, has been required of all new wheats released by the Department of Agriculture.

This has been achieved by flag smut resistance trials which were commenced in 1926 at the Merredin Research Station by Carne and Limbourne. The technique used was simple. The seed was inoculated with flag smut spores before sowing, and varietal resistance was assessed from the numbers of diseased plants which developed. However, infection ratings must be maintained yearly at the highest possible level, so that susceptible material can be sorted out at an early stage ; otherwise the wheat breeding programme will be seriously delayed. At the Merredin Research Station this difficulty fortunately did not arise, but when, some years later, wheat breeding was also undertaken at the Wongan Hills Research Station, the work was greatly hindered by the low and variable infection ratings obtained.

In 1941 and 1942 this matter was investigated and it was found that the chief causes were (1) lack of uniformity in the purity and amount of inoculum applied to the seed, (2) low soil pH, (3) late and shallow planting. These difficulties appear to have been overcome by the application of this knowledge, for during the last two seasons flag smut infection ratings at Wongan Hills Research Station have closely paralleled those at Merredin, and no trouble has been experienced in separating susceptible from resistant varieties.

*Certified Potato Seed.*—Another noteworthy contribution in the field of plant pathology relates to the potato certified seed scheme which aims at keeping our potato crops as free as possible of virus diseases.

About the year 1924 the yield of locally grown Delaware potatoes started to decline noticeably and the matter gave grave concern. The true cause—a gradual accumulation of viruses—was then unknown, and so it was assumed that the variety was undergoing the traditional " degeneration " or " running out " process. Fortunately, it was noticed that reduction in yield was greatest where the condition known as " crinkly leaf " was most in evidence, and in an endeavour to eliminate these " off type " plants, Mr. G. N. Lowe, Senior Potato Inspector at the time, devised a potato seed certification scheme. The scheme provided for the certification of summer crops in which " rogueing " of crinkly leaf plants had been carried out by the grower to the satisfaction of a departmental inspector. The tubers were also examined for size and the presence of visible diseases, e.g. common scab and rhizoctonia. In 1926 the first parcel of certified seed, 32 bags in all, was certified in the Brookhampton area. This year is also notable for another event, potato viruses being recorded here for the first time. Carne recognized both the leaf roll

and the mosaic virus diseases, and the latter proved identical with the " crinkly leaf " condition previously associated with our declining yields. Thus it became evident that the so-called degeneration of the Delaware variety was due to virus diseases, and that the certification scheme was soundly based.

It was soon found that certified seed gave improved yields except in one or two isolated cases, and as a result it commanded £3-£4 per ton above ruling rates. Consequently, growers were soon clamouring for their crops to be certified and by 1930 approximately 10,000 bags of seed were available. Good headway had now been made in arresting the declining yields and for the 10-year period ending 1930 our average yield per acre was 3·6 tons, compared with the Australian average yield of 2·6 tons.

However, scientific knowledge concerning the potato viruses also grew apace at this time ; it became known that in hot weather, symptoms of the main viruses became more or less masked, and that accordingly the summer crop is not an ideal one to certify. The use of winter stud seed plots was therefore recommended by Pittman and Elliot, and this was adopted by Mr. E. T. Morgan, who succeeded Lowe. Due to Morgan's initiative, other modifications were also put into practice. Gradually he confined the raising of certified seed to more suitable districts in the lower south-west, and in 1937 he introduced the " tuber unit " system of planting the stud plot with further marked improvement in yields. The result of all this work is best appreciated from the State average yield, which rose from 3·6 tons per acre for the 10-year period ending 1930 to 4·8 tons for a similar period ending 1940, or an increase of 33 per cent. There is little doubt that this great improvement in yield was almost entirely brought about by the reduction of virus diseases through seed certification.

It may be as well at this stage to sound a note of warning, pointing out that what has taken years to build up in the way of comparative freedom from virus diseases, may be ruined in a much shorter time, unless constant supervision is practised. Conversely, with increasing attention paid to the production of good quality certified seed it is quite possible for yields to be further improved.

## Present Activities and Problems.

It is pertinent at this stage to indicate something of the scope and nature of plant pathological work which is being carried out in Western Australia at the present time. From the historical introduction already presented it is evident that from early times a Department of State has been wholly responsible for our plant pathological activities, apart from a few investigations in which C.S.I.R. officers were engaged. This position still holds, though one gratefully acknowledges the increasing assistance which is being rendered by the press, the Royal Horticultural Society and affiliated societies, etc., in the dissemination of information supplied to them.

Since the war commenced, major activities have been concerned with the preparation and distribution of cultures for leguminous plants and with the diseases of priority crops, especially vegetables and flax.

At first sight, there would appear to be little connection between plant pathology and a rhizobial culture service ; but the link was forged in 1926 when it was discovered that unhealthy stands of lucerne, very common at the time, were due to lack of the requisite nodule-forming bacteria in the soil. Since then the service has grown tremendously owing to good results which have followed the sowing of inoculated seed in many districts.

During war-time, the service has assumed even greater importance than formerly, owing to the urgent need for conserving nitrogenous fertilizers. Orchardists and market gardeners especially are now relying considerably on the practice of green manuring with legumes grown from inoculated seed, in an endeavour to maintain soil nitrogen at a sufficiently high level for crop production. During the last four

years an average of more than 2,000 cultures has been distributed yearly, and a locally isolated strain for the inoculation of New Zealand lupin is giving excellent results both here and in Victoria.[3] The effectiveness of stock strains is tested frequently, and search is constantly being made for improved strains.

*Vegetable Growing.*—Turning now to vegetable growing, the urgent need for maximum vegetable production has introduced special problems. Generally speaking, in pre-war days, the market gardener made few requests for plant pathological assistance, compared with the fruit, cereal and potato growers. This was certainly not because the market gardener had no plant disease problems ; nor was it due merely to apathy on his part, as some have suggested. Probably it was related to language difficulties, and to very infrequent contact with advisory officers, in contrast to the other primary producers mentioned who were much better catered for in this respect. It is believed that more than 90 per cent. of market gardeners in the near metropolitan areas are southern Europeans, many of whom are unable to speak or readily understand English, and their apparent apathy in seeking assistance can thus be readily understood.

On the other hand, a number of our biggest vegetable growers are Australians, and they have always brought their difficulties under notice when necessary. However, the war-time drive for increased vegetable production served to draw attention to the losses caused by vegetable diseases and to the need for more research and advisory work. As a result more than fifteen new diseases have been identified and other necessary information has been collected on which a more useful advisory service can be based. Owing, no doubt, to more frequent contact with departmental officers since the war, there is a noticeable improvement in the application of this knowledge to practice ; but there is still room for greater improvement. Printed literature fails badly to achieve this, for from enquiries made within recent months it seems certain that less than 10 per cent. of vegetable growers receive either the agricultural journal or advisory leaflets ; and those who do are British-born. Extension work through the medium of personal contact and by demonstrations at selected centres appears to be the most suitable method, and a progressive growers' organization, active not only in the political but the educational sphere, would help considerably.

*Flax Growing.*—The new flax-growing industry which has developed here since the war has also been confronted with plant disease problems. Of these, flax rust is easily the most serious at present, but other diseases such as browning and anthracnose which are now of little consequence may perhaps become more troublesome in future. Flax rust is proving a major limiting factor to production, and unlike stem rust of wheat, climatic conditions each season seem favourable for its development. It has been estimated that, in 1942, on the fibre varieties, flax rust caused a 20 per cent. reduction in straw yields, plus a 10 per cent. reduction in straw values, and it has proved even more serious on the linseed varieties.

It is noteworthy that investigational work relating to the various diseases of flax has been organized on a Commonwealth-wide project basis by Dr. I. F. Phipps, technical officer to the Flax Production Committee. This set-up is an ideal one for solving the various problems expeditiously, and all States are giving the fullest cooperation.

In Western Australia, plant pathological work has mainly been concerned with flax rust, and particularly with those aspects bearing on the breeding of resistant varieties. This is the only satisfactory method of controlling the disease. Unfortunately the flax rust fungus is highly specialized, for it comprises numerous physiological races which vary in the varieties they attack. A knowledge of the races present and their distribution, in the regions where flax is to be cultivated, is therefore a prerequisite to the success of any breeding programme. In Australia, the race determinative work is being carried out by Dr. W. L. Waterhouse of Sydney

University from rust collections made in each State. To date, eight races have been determined in Australia and five of these occur in Western Australia.

As flax and linseed growing on a commercial scale have only been attempted so recently in Western Australia, it may well be asked, " How did the disease originate here and become widespread so quickly ? " It is known that flax rust may be introduced with badly cleaned lines of seed, and probably in the past outbreaks of rust in small trial plots which have been grown here from time to time were caused in this way. However, all imported seed used for commercial production in Western Australia since the war has been thoroughly cleaned and so this method of disease introduction may be ruled out. It has now been found that the native " wild flax ", *Linum marginale*, which is endemic to Australia, plays an important part in the occurrence of the disease. It is important not only as a perennial hold-over host from which the disease spreads to commercial crops, but possibly together with self-sown flax it plays an important part also in the evolution of new races. Wild flax, much of it badly rusted, has been discovered during the last two years in many localities between Kellerberrin in the north and Bremer Bay in the south, and three races of the parasite have been identified from local collections. One of these was found as recently as last October on plants growing at Bremer Bay, and the race proved to be new both to the State and to the Commonwealth.

Although good progress has been made, it is unlikely that the flax rust picture is yet complete, and resistant varieties of good commercial character are not yet available. Until they are, other methods of limiting the disease are important. These include stubble burn to reduce the amount of self-sown growth, crop rotation, and the use of well-cleaned seed.

## Future Trends.

In the past, plant pathological activities in this State have been concerned almost entirely with the problems of the primary producer, and especially with the diseases of such economically important crops as wheat, apples, potatoes, etc., for which an export market formerly existed. Of necessity, little attention has been paid, until recently, to the requirements of the home gardener, despite an increasing need for assistance. Within the last decade, there has been a noticeable increase in the popularity of home gardening pursuits, and this interest is now being turned to good account in the home growing of vegetables. It is to be hoped that future policy will not be governed solely by economic considerations, for surely social and aesthetic values should also be taken into account.

However, even if this is not conceded, it may be mentioned that according to three leading nurserymen the present sales of home garden requisites (including shrubs, seedlings, flowers and bulbs) amount to approximately £70,000 per annum. In pre-war days this figure was even greater, and no doubt it will also be exceeded in post-war years. It is believed that a working knowledge of plant diseases will increase rather than detract from the pleasures of home gardening.

More attention could also be profitably paid to nurserymen's problems, and one hopes that it will not be long before they recognize the advantages to be derived from the employment of well-trained agricultural graduates.

## Organization.

Within the various fields of plant pathology, e.g. virus, fungal, bacterial, tremendous advances have been made, especially during the last twenty-five years, and each field is now so comprehensive that specialization is being increasingly adopted, both in research and advisory work.

This trend is also apparent in Australia. In 1930 there were 23 full-time plant pathologists working in Australia, excluding those whose main duties were educational. Of these, 57 per cent. were engaged in work of a general nature, and

the remaining 43 per cent. were specialists, in the sense that their work was more or less restricted to certain host or parasite fields. At the outbreak of the war, the total number had grown to 35 and the proportions of each were practically reversed. Specialist workers had increased by this time to 60 per cent., while the number of workers engaged in general plant pathology had declined to 40 per cent. Later figures than these are not applicable owing to enlistments and transfers.

In Western Australia little opportunity has yet been afforded for specialization, and for many years pathologists here have largely been occupied with routine work, and the provision of a general advisory service. During war time, of course, the demand for work of this kind has inevitably increased. No doubt a very wide and useful range of experience with all kinds of diseases is gained in this way, which is denied to workers elsewhere with more specialized interests.

On the other hand, this trend makes it increasingly difficult to give more than superficial attention to the more fundamental aspects of problems which are of great importance to this State. Isolation from colleagues with similar interests and a long deferred knowledge of the work that is proceeding in other States are also serious handicaps.

These could be overcome to some extent, at least in the post-war years, by closer cooperation between States when similar problems are being investigated, and by the frequent circulation of plant disease notes, along lines similar to the American "Plant Disease Reporter" publication. Needless repetition of work might be avoided; contact between workers would be stimulated, and a speedier solution to problems might be achieved by these means.

In conclusion, it may be said that just as plant pathology has worthily contributed to agricultural progress in the past, so in common with other branches of agricultural science it can play an increasingly useful part in future.

Whatever the pattern of agriculture may be in post-war years as a result of either free-trade or economic nationalism, there is little doubt that production costs must be as low and yields as stable as possible. Plant pathology can help to achieve this and it can also help to prevent much wastage of human effort.

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# Irrigation and the Wool Industry

By

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The amount of rainfall and the variability of its incidence are the two major climatic features of Australia which determine agricultural and pastoral production. The low average over a great portion of the Commonwealth (see Table I), coupled very often with low reliability, reduces land usage in those parts to nil, or at most only sparse grazing, whilst on much of the area that appears to have a better average precipitation, unreliability alone renders production precarious.

The proportion of the continent where rainfall is in excess of requirements is relatively small, so that the amount of water that can be conserved for conveyance to the drier areas, even granted no engineering difficulties, is insufficient to irrigate more than a very minor proportion of the land suitable for irrigation.

Table 1.

*Percentages of the area of continental Australia receiving various average annual rainfalls. (Compiled from Commonwealth Year Book, 1940.)*

| Under 10 ins. | 10–15 ins. | 15–20 ins. | 20–25 ins. | 25–30 ins. | 30–40 ins. | Over 40 ins. |
|---|---|---|---|---|---|---|
| 36·2 | 20·5 | 12·1 | 10·3 | 7·6 | 7·1 | 6·2 |

## The Cost of Water Conservation.

Experience in Australia has shown that the actual users of irrigation water can just about afford to pay for maintenance charges of reticulation systems and costs of distribution, the total capital expenditure and headworks maintenance being of such magnitude that, were these included in the water charges, the majority of present consumers would find it economically impossible to irrigate.* The Australian community has invested in irrigation and it is clear that the nation should safeguard its investment. To do this, control should be exercised over the use of water by growers. To this end, two conditions must be observed:

(*a*) that the water be used to irrigate those crops whose production will most benefit the national economy, and

(*b*) that the water be used on the chosen crop or crops to its maximal efficiency, eliminating as far as possible waste due to losses in conveyance and to inefficiency on the farm, both of which losses are considerable.

## The Economic Importance of Various Crops under Irrigation.

The Commonwealth Year Book annually publishes a table showing the respective acreages of each crop under irrigation, but no data are available to show the relative amounts of water used by each industry. This is unfortunate from the point of view of making an economic assessment of irrigation water usage. However, it is interesting to examine the individual economics of the several major industries that make use of conserved water.

* Of Victoria's expenditure of £12½ millions on irrigation, £11 millions have been written off, leaving the remainder to be carried by the growers. The principle of governmental supply of "the whole or part of the headworks and main supply works free of any charges against the settlers directly benefiting" was agreed to in a resolution at the Interstate Conference on Water Conservation and Irrigation, Sydney, April, 1939.

*Horticulture.*—In the early history of irrigation farming in Australia, the main use of water was for horticulture. Production expanded until the home markets were saturated, and until the exportable surplus was in excess of what overseas markets could absorb at a price profitable to the grower. Consequently, plantings were restricted, even though water and land were available, and bounties had to be paid by the nation to the growers to enable them to sell the surplus at competitive overseas prices. Wine, oranges, lemons, grapefruit, mandarins, pears and prunes, a great proportion of which crops are users of conserved water, have all been subsidized with export bounties at some period or other, £2,097,000 being paid between 1935 and 1940 alone.

*Rice.*—With the inability of dairy farmers to make a success of irrigation in the early days of the Murrumbidgee Irrigation Area, rice became an important crop in that district from 1925 onwards. Though high average yields are obtained, the volumes of water used are very high, over seven acre-feet being required to produce 1·7 tons of paddy. Water is delivered to the grower at five shillings per acre-foot, whereas horticulturists pay ten shillings. (Even this latter figure approximates to only half the full cost of conservation and conveyance.) A tariff of 1*d.* per lb. on paddy, and 1½*d.* per lb. on milled or other rice has had to be proclaimed to prevent the consumer purchasing the imported product. Table 2 illustrates the monetary return on water usage on the Murrumbidgee Irrigation Area, 1941-42.

TABLE 2.

*Water usage for, and monetary return from, rice production on the Murrumbidgee Irrigation Area, compared with total water usage and monetary return in that area, 1941-42. (Compiled from Annual Report of N.S.W. Water Conservation and Irrigation Commission, 1942.)*

| | All Crops. | Rice. | |
|---|---|---|---|
| | Total. | Total. | Percent. |
| Water used, in acre-feet .. .. .. | 349,000 | 170,000 | 48·7 |
| Return to growers.. .. .. .. | £2,067,000 | £445,200 | 21·5 |
| Return per acre foot .. .. .. | £5·1 | £2·6 | — |

*Wheat.*—Quite a large proportion of conserved water is used annually to supplement the autumn rainfall for the production of winter cereals, particularly wheat. The great bulk of this is for grain—nearly half a million bushels being produced on the Murrumbidgee Irrigation Area alone in 1939-40—and enters normal sales channels. Bounties paid by the Commonwealth Government between 1931 and 1941 to Australian wheatgrowers totalled over £21 millions, so the use of water to augment production of this crop does not appear to be sound financially.

*Dairying and Fat Lambs.*—Most pastures and fodders grown under irrigation are used for dairy and fat-lamb production. Country which was devoted mainly to wool growing before the provision of irrigation facilities has, depending upon the amount of water available and the consequent proportion of land irrigated, changed its livestock types and methods of husbandry, and, on the irrigated land, the carrying capacity has been increased.

Butter production is greater than Australian consumption and, to reduce the price of the exportable surplus so that it can be sold on overseas markets, an Equalization Scheme is in operation to increase the home price and so give a payable return to the producer. Expansion of butter production will involve higher local prices unless home consumption increases, and higher prices are not likely to be paid if edible vegetable fats are cheaper.

Of Australia's mutton and lamb production, 73 per cent. was home consumed in 1938-39, and of the remainder 97 per cent. was exported to the United Kingdom. Though the stability of the export trade depends largely on the terms of the Ottawa

Conference of 1932, which may be altered after the war, it has been suggested that meat exports will assume greater significance in future world trade. The use of irrigation water for meat production may, therefore, be quite sound policy.

At present, water is being used to increase carrying capacity for lamb production on the small proportion of irrigated land, and drought protective measures aimed at stabilizing the flow of output are not by any means the general practice. Since evenness of output is an important factor in price returns the use of irrigation water for meat production would appear to be more soundly based on this latter aspect, than on supporting a temporary increase in normal years.

*Wool.*—Only a very small proportion of the water resources are used for the production of pastures or fodders specifically for the stabilization of the wool industry. Yet, this is the Commonwealth's most valuable industry, unprotected by tariffs, unsubsidized by bounties, annually contributing almost half of the export wealth, but experiencing large fluctuations in production due to an erratic rainfall, and suffering severe losses by drought.

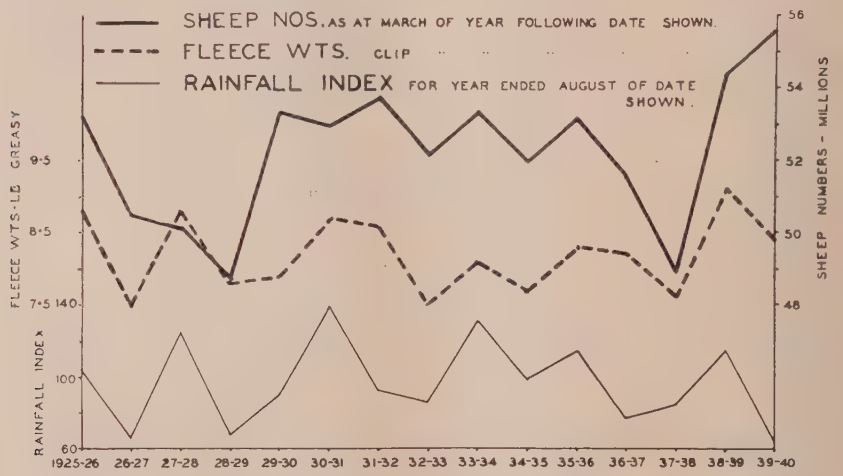


*Figure* 1.

Dependence of sheep numbers and fleece weights upon rainfall in the sheep districts of New South Wales, 1925–1940. (Compiled from N.S.W. Official Year Books.)

Of Australia's exports of all commodities in 1939-40, which totalled £147 millions, wool contributed £57 millions and meats £15 millions, the pastoral industries as a whole (excluding dairying) aggregating £78 millions or 53 per cent. Some idea of the extent to which rainfall affects the pastoral industry may be gauged from Figure 1. In examining this graph, it must also be remembered that in years of a small wool clip, the total sum received by producers is on the whole greater than for a large clip, which, taken at face value, would lead to the erroneous conclusion that droughts are an advantage. Hartley,[4] in discussing this situation, arrives at the conclusion that " there seems to be ample justification for research designed to overcome seasonal fluctuations, or to improve the lot of the marginal producer ".

Another very important factor that must be considered is that much of the arid and semi-arid areas is of little use except for sheep grazing, so that if the wool industry declines because of high production costs, or because of other reasons, then a very large proportion of the continent will gradually contribute less and less to the national income.

Where, therefore, the national investment in water conservation and irrigation can be applied to the stabilization of the pastoral industry, it would appear that the use of water for this purpose would better serve the interests of the community than its use in augmenting production of uneconomic crops.

### Stabilizing the Wool Industry.

The production under irrigation of cheap supplementary pasturage and fodder of the right type would be a substantial contribution to the individual grazier and to the stabilization of the wool industry as a whole. Such use of irrigation water necessitates an approach of completely different character from intensive irrigation such as horticulture, rice, wheat and even dairying, where the aim is maximal return per unit of land. The production of these latter crops, particularly horticulture, requires the development of closely settled areas. This involves high capital and maintenance costs which must be at least partly repaid by a high yield from high quality crops. Consequently, water is made available as far as is practicable in completely sufficient quantities and at the correct times to serve those ends.

With pastoral irrigation designed to stabilize an existing widespread industry, it becomes necessary to spread the available conserved water over as great an area within erratic rainfall districts as possible, so that each property may have a fair share. Then it becomes the responsibility of each landholder to use his quota of water on the soil type and over the acreage of suitable land that will most benefit his livestock as a whole. The objective on each irrigated acre is the optimal, not the maximal, yield per unit of water.

Nor is yield alone the criterion of efficient pastoral or fodder irrigation. Bull[1] states that a high protein content is necessary for wool production, and a steady supply in the diet is necessary for evenness of staple. But the native pastures, which in the greater portion of the sheep areas cannot be replaced by introduced pastures, do not fulfil this function. Lines[5] points to summer and early autumn protein deficiency in the winter rainfall zone, and Davies[3] to irregularity of protein supply in the zone of summer rainfall. Consequently, the greater the amount of actual protein as pasturage or conserved fodder that can be obtained by irrigation from each unit of water for the purpose of supplementing the native pasture in periods of protein deficiency, then the greater is the degree of stabilization to the sheep industry within and surrounding the irrigation districts.

### Existing Irrigation Areas.

The use of present irrigation areas for the purposes of livestock protection depends on their proximity to sheep districts of low or erratic rainfall.

Those within the region comprising the statistical divisions of Northern Victoria and the Riverina of New South Wales do offer the means of stabilization and drought mitigation to a large livestock population. Taken as a whole, the two divisions cover 21,500,000 acres of occupied land (holdings one acre and over) within which it is proposed that the area of irrigated pastures and fodder crops will eventually total 867,000 acres. In the Victorian section, the general practice is to make sufficient water available to irrigate 30 per cent. to 100 per cent. of each holding supplied, but in the Riverina (except within the intensively irrigated Yanco and Mirrool areas) the proportion is, or will be, in the vicinity of only 10 per cent.

This region carried 9,590,000 sheep, 120,000 registered dairy cows and 192,000 other cattle in 1940.* Included in the sheep population (equivalent to 7·8 per cent. of the Australian total) was 11·0 per cent. of the Commonwealth's rams, the majority of which were Merinos. This indicates the importance of the region as a breeding centre for the wool industry and is an added reason for the utilization of irrigation water as a stabilizing factor.

* The previous year, 1939, marked the end of a severe drought, and the figures then were 6,717,000 sheep, 106,000 registered dairy cows and 129,000 other cattle.

However, the present policy has not been in general along such lines. As irrigation facilities were extended in Northern Victoria, properties so supplied changed from insecure cereal and fluctuating wool production to dairying and fat-lamb raising. In 1940, only 20 per cent. of the rams were Merino, Corriedale and Polwarth, the remainder being British breeds. A similar change is taking place in the new irrigation areas in the Riverina.

It is suggested on the basis of the foregoing discussion that such use of irrigation water is not in the best interests of efficient land and water utilization. Particularly is this so in the Riverina, where the proportion of unirrigated land is very high.

## Future Irrigation Areas.

Regarding future water conservation projects in Australia, pastoral stabilization depends upon the possibility of setting up irrigation facilities supplied by such projects within sheep districts of low or erratic rainfall, or in areas, such as the summer rainfall zone, where the normal irregularity of protein supply results in slow and interrupted growth of animals and their products. The utilization of such pasturage and fodder must be supplementary to the greater area of surrounding natural pasture if the resources of the Commonwealth are to be used to their greatest benefit. For this reason, any future conserved water could well be shared amongst the greatest number of grazing properties in proportions equivalent to their necessities, as has been done in the Riverina.

## Efficiency of Water Conveyance.

Seepage and evaporation losses increase the further the distributary channels extend from the conservation site, evaporation particularly becoming higher as the channels reach out into more arid country. Clifton[2] estimates a 40 per cent. conveyance loss for the Collie Irrigation Area in Western Australia. Tandy[7] in an investigation of artesian bores estimates a 65 per cent. loss by seepage* and a 25 per cent. loss by evaporation, making a total of 90 per cent., from the bore drains in north-western New South Wales. Obviously, then, water conveyance to irrigation areas presents a serious problem, but since it is an engineering one, it need not be further discussed here, except to state that it imposes severe limitations on the distribution of water to graziers in the more arid regions.

## Efficiency of Water Usage on Each Sheep Property.

The attainment of maximal wool quality and quantity per unit of irrigation water involves an analysis of the factors that affect such production. The soil, the pasture or fodder plant and its relation to the soil and soil moisture, irrigation methods and grazing management between irrigated and unirrigated land are some of the many contributing factors. Coordination of such factors into a practical pastoral irrigation programme is a necessary concomitant to efficient water usage.

On intensively irrigated pastoral areas devoted to dairying and fat-lamb raising, considerable skill and efficiency has been attained, but the results do not lend themselves to direct application to extensive areas devoted to supplementing the diet of livestock on natural pasture country. Moreover, on these new extensive areas wasteful methods have arisen such as the practice of flooding native pastures. In 1941-42, over 58,000 acres of native pastures were irrigated in four districts in New South Wales, and it is a practice in two other districts in that State, and to a much less extent, in northern Victoria. Smith *et al.*[6] describe it as a " pernicious practice which will cause a rapid deterioration of grazing land if it is allowed to persist ".

* Tandy discusses various means for improving channel surfaces to reduce this wasteful loss materially.

## Conclusions.

The wool-growing areas of Australia are, on the whole, situated in regions of rather low and erratic rainfall. As a result, the native pastures undergo considerable fluctuations in quality and quantity, and this is reflected in both sheep numbers and the yield and quality of the wool. The industry is the major contributor to the nation's wealth, and therefore deserves stabilization to protect it from the inconsistencies of the rainfall. Quite a degree of stabilization would be afforded if cheap pasturage or fodder could be provided to supplement the deficiencies of the native pastures. To a large extent this could be done by giving the industry a major share in the water that has been conserved by national expenditure. But because the amount of water that is, or could be, conserved falls short of requirements, a high degree of efficiency of water usage is necessary so that the benefits could apply to as large a proportion of the flocks as possible. The native pastures would also benefit by being relieved of overgrazing during periods of shortage.

It must be stressed, however, that the scheme aims at the stabilization of an existing industry, definitely not at an increase of its production, which latter would result in increased misuse of the native pastures and an economic upset in the industry.

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# The Need for Wool Research in Australia

By

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In an article entitled " Research and the Future of Wool ", Stewart[7] discusses two articles by Penfold[6] and Clunies Ross[1], and offers a frank and " realistic appraisal " of the threat from synthetics and of the need for any marked expansion of biological research in relation to the Australian wool industry. In so far as the criticism of the writer's proposals for wool and textile research relates to the details of those proposals, it is to be welcomed, since they were put forward nearly a year ago as a tentative basis for discussion. But when the need for an extension of biological research is questioned his statements merit a candid analysis.

An attitude not uncommon amongst wool producers is adopted of seeing every opportunity for improvement in those sections of the industry outside his control, while being reasonably satisfied that in his own field everything is, if not " the best in the best of all possible worlds ", at least such as to give him justification for plucking the mote from the other fellow's eye while neglecting the beam in his own. The buyer and manufacturer are, of course, given to the same practice.

Surely there is urgent need, in the face of the threat from synthetics, actual or potential, great or small, and of a world surplus of some 10,000,000 bales (Australian equivalent) of greasy wool, for all who have the interest of the industry and Australia at heart to see that, at whatever cost of money and manpower, the highest degree of efficiency is attained in all sections of the industry, and not least in that of production.

## Synthetics and Wool Manufacturing Costs.

It is necessary to examine Stewart's assessment of the present danger from synthetics and secondly his argument that, since raw material costs play so little part in the price of the finished article, any reduction in these is of little importance to the future of wool.

In regard to synthetics, the conclusions to be drawn from Stewart's analysis are that, in estimating the ability of synthetics to replace wool, sufficient attention has not been paid to the bio-physico-chemical structure of wool, and that until such time as synthetics are endowed with this structure, their effects on demand for wool are not likely to be serious. Similarly, he implies that no synthetic has reproduced such individual characters of the wool fibre as its tensile strength, resistance to bending, elasticity, etc., in spite of the many claims to the contrary, some of which, unfortunately, appear to be soundly based.

Regrettably, neither the wool manufacturer nor the man in the street is consciously concerned with the bio-physico-chemical structure of wool, but the one with fabric he can sell and the other with fabric he can buy. Today, in Sydney, " wool-like " dress fabrics are selling freely which are made entirely of synthetic fibres and, in the opinion of experienced buyers of large retail houses, who so largely determine whether wool or substitutes are offered to the public, are giving every satisfaction. Again, as long ago as 1939, the International Wool Secretariat had the experience of finding that some of the knitted " wool " garments selected by fashion experts for a wool display in New York contained up to 90 per cent. of synthetic fibres. Similarly, in London in 1939, knitting " wools " and striped dress flannels were placed on the market containing 50 per cent. of synthetic fibres and sold at a considerably lower price than " all wool " yarns and fabrics, because of the difference in price of the " raw material ". One can, of course, hope that the deficiency in the

bio-physico-chemical structure of these materials may at some time become apparent to the buyer, who is the ultimate judge, but it would be unwise to wait for this to happen, or to assume that it will.

The statement may now be considered that not raw material costs but wholesaling and other distributing charges are all-important to the future of wool. This is, of course, the current complaint of the producer against the supposed rapacity of the manufacturer and distributor. In fact, the relationship of raw material to finished or other costs of wool is not of prime significance, except in so far as it reflects the effects of the small-scale organization and the involved and expensive nature of present methods of wool processing. What is important is the relationship of such costs at all stages of processing and manufacture to those of competitive fibres. Here again, a few instances from actual experience may be more expressive than a theoretical discussion. In 1937, up to September, wool prices had risen sharply. At this time the writer had occasion to discuss with one of the largest manufacturers of men's clothing in Great Britain—a man whose activities had had a significant influence on maintaining demand for wool—what effect this rise would have on his fixed price ranges for suits. The reply was that the manufacturer would continue to use wool until such time as tops reached 40*d*. (he used largely Australian Merino wool), but thereafter he must either increase his prices or use sufficient of the cheaper staple fibre to hold his top prices within the permissible limits. He left no doubt as to which course he would choose.

Similarly, the managing director of the firm making by far the largest volume of ready-to-wear men's clothing in the United States stated to the writer quite frankly that his firm would always maintain their standard price of $29.50, and when wool prices rose would add a proportion of staple fibre. It may be noted that admixture of staple fibre in this instance would lead to no lessening of cost to the consumer but only a displacement of wool. In fact, the argument that admixing staple fibre may be beneficial to wool by cheapening cost is a dangerous one, because of the very fact that the raw material cost is only a proportion of the total cost of the finished cloth, so that displacement of 30 per cent. of the wool may result in only a 10 per cent. reduction in cost, i.e. a release of 10 per cent. additional purchasing power. That this may in some cases lead to additional demand for wool of a greater order than 10 per cent. is capable of argument, but it has not the significance so often attributed to it.

## Cost of Wool and Retail Prices.

Apart from the above examples, nothing could be less happily chosen than the illustration of the discrepancy between raw material and retail selling costs. It is implied that in normal practice the margin between manufactured cost and wholesale selling price is as 8*s*. 1*d*. to 21*s*. 9*d*., or 250 per cent. It is of course possible that actual examples of such charges could be cited, but they have no possible relation to normal practice in any major field of wool consumption ; the highly competitive nature of peace-time textile merchandising would speedily lead to the elimination of any firm attempting such a practice.

In contrast to the price of 21*s*. 9*d*. per yard wholesale quoted as being apparently representative, two very large organizations in Great Britain will make a finished three-piece suit to measure containing on the average 3½ yards of 12-14 oz. worsted cloth for £2 10*s*., after bearing all tailoring and retail charges. Again, a certain large British chain store organization will provide a wool cardigan or skirt for 5*s*. retail. It is needless to state that their suppliers, whether spinners, knitters or manufacturers, are concerned to save even 1*d*. per pound in costs of tops and yard or per yard of cloth. In fact, the closer one comes to this rationalization of manufacture and distribution, of which Stewart emphasizes the need, the more vital do raw material costs, whether of wool or synthetics, become. In any case, the horizontal stratification of the British worsted industry makes similar margins of

importance at various stages of processing and manufacture. It may be mentioned that at the present time the fixed margins allowed the wholesaler in Australia are 12½ per cent. (25 per cent. of the piece is cut) on women's dress materials and 7½ per cent. on men's worsteds.

Contrary to Stewart's figures, the greatest margins are exacted by the retailer—other than in the case of firms cited above, which are both wholesalers and retailers—and his margins are normally from 50-75 per cent., though in the case of one London firm with a fashionable clientele the retail margin, because of lavish display and advertising, was up to 125 per cent. By contrast, the 30 per cent. margin of London merchants was modest, as the writer's personal experience attests. That a suit length purchased from such a merchant or wholesaler for £2 2*s*. 3*d*. costs another £8 8*s*. when made up by a West End tailor is beside the point—both wholesalers and merchants were interested in price differences of 6*d*. per yard. It should be borne in mind also that wholesale and retail and other distributing margins apply to other textile fibres besides wool and to those fibres mixed with wool.

An example of the effect of high raw material costs on all subsequent stages of manufacture is offered by the United States, where the imposition of a wool tariff, which reached a high point of 34 cents per pound (scoured) in 1930, and the subsequent rise in domestic raw wool prices has increased the cost of wool fabrics in relation to other textiles, and, in the opinion of many competent observers, has seriously weakened the position of wool in that country. He would be a brave man who would state that the lifting of the United States wool tariff would not influence wool consumption.

The foregoing discussion would be irrelevant to the desirability of reducing costs of production in Australia were it not for the tendency of the uncritical to accept such arguments as those put forward by Stewart as justification for neglecting this aspect of the interrelated problems of the wool industry. The purpose of reducing costs of production is to ensure the maximum return to the individual grower and the country, and this is no less necessary in peace than in war, or in the presence or absence of threats to wool's future. The future price of wool will not be determined by growers' costs but by demand for wool, which in turn will be influenced amongst other things by the competition of synthetics and other fibres and the premium which users are prepared to pay for wool because of its intrinsic merits, over and above the price they are prepared to pay for synthetics. The effect of that price on the wool grower will be largely determined by his costs of production, every reduction in which will strengthen his position against a fall in prices, while ensuring him the full benefit from any rise. The price of wool will not be affected by costs of production, but in relation to those costs will determine whether wool production is profitable or not.

## The Necessity for Research.

Having these facts in mind, let us now examine critically the statements and conclusions of Stewart deprecating the need for an extension of biological research.

He assumes that the wool textile industry in the future, as in the past, will continue along its traditional path, lacking definitions of "quality" and "handle" and other fleece characters, or scientific standards of measurement and appraisal, and that the scientist sharing this ignorance and apathy has no other duty than to see that the wool grower produces the maximum weight of wool of as great a variety of types as chance may determine. In support of the policy of *laissez faire* it is stated that, granted a number of assumptions, any refinements in quality or in definition of wool characters can be of significance only in relation to the worsted trade which, it is alleged, is of far less importance quantitatively than the woollen trade. In fact, even quantitatively in terms of virgin wool, the position in all major wool-importing countries in peace-time is exactly the reverse. Stewart

ignores the fact that the woollen trade consumes large quantities of reclaimed wool, while he apparently takes no account of the very great preponderance of worsted yarns used in the hosiery trade.

The relative importance of the two sections of the industry is shown in Table I.

TABLE 1.

*Consumption of Virgin Wool (from World Consumption of Wool*[5]).

| | Worsted. | | Woollen. | | Hosiery. | |
|---|---|---|---|---|---|---|
| | Million lb. | Per cent. | Million lb. | Per cent. | Million lb. | Per cent. |
| U.S.A., 1931 : | | | | | | |
| Total.. .. .. | 115 | 45·0 | 100 | 39·0 | 40 | 16 |
| Noils and wastes .. | — | — | 33 | 13·2 | — | — |
| United Kingdom, 1934 : | | | | | | |
| Total.. .. .. | 150 | 37·5 | 190 | 47·5 | 60 | 15 |
| Noils .. .. | — | — | 20 | 5·0 | — | — |
| Wastes .. .. | — | — | 30 | 7·5 | — | — |

In 1935, the hosiery trade used approximately 80 per cent. of worsted yarns in the United States, while the proportion in the United Kingdom certainly would not be less.

The author of the above figures concludes that the woollen industry of the U.S.A. and U.K. consumes only 40 per cent. of the total virgin wool, and of this 40 per cent. almost one-third is in the form of noils and wastes, while, in addition, it largely utilizes the less valuable and coarser wools.

The position in France exemplifies the importance of the worsted trade even more strikingly, as shown by the comparison in number of woollen and worsted spindles, while in Germany and Belgium the comparative position corresponds roughly to that in Britain and the United States. Actually the German worsted industry in 1937 consumed 71 per cent. of the virgin wool processed and the woollen industry only 29 per cent. other than noils and wastes.[4] The figures are given in Table 2.

TABLE 2.

*Number of Woollen and Worsted Spindles (from World Consumption of Wool*[4]).

| | Woollen. | Worsted. |
|---|---|---|
| France .. .. .. .. | 626,000 | 2,116,000 |
| Belgium .. .. .. | 376,000 | 450,000 |
| Germany .. .. .. .. | 2,426,000 | 3,211,000 |
| United Kingdom .. .. | 2,600,000 | 3,000,000 |
| United States .. .. .. | 1,508,000 | 2,168,000 |

Is it really necessary, however, for intelligent Australians, above all men, to waste time in disputation about the desirability of ascertaining the possible significance of any and every character of wool which *may* have an influence on its value to the manufacturer or the producer, or of understanding how each and every one of these characters is influenced and may be controlled by heredity or environment ?

## Biological and Economic Research.

Stewart, while admitting that we " know little of the method of inheritance of attributes of great economic importance ", states that we know enough about methods of selection " to provide a most powerful tool for the selection and propaga-

tion of these attributes ". It may be asked are we to continue to know little, are we to continue to rely on the present powerful tool, the limitations of which on theoretical as well as practical grounds are understood by all geneticists and many intelligent graziers, or are we by every means in our power going to accelerate our efforts to understand the method of inheritance of these attributes, whether of present or potential importance ?

Far from overlooking the fundamental and applied investigations which have been or are being made in the realm of nutrition, agrostology, and pasture management, the present writer claims that, in relation to the magnitude and diversity of the problems, they are grossly inadequate and will not at the present rate of progress meet the needs of the industry for generations to come. The assertion that the relative economic returns from various types of pasture management are already " acutely assessed " by the grazier amounts to a belief that in Australia the virtually undeveloped field of agricultural economics may be neglected, that the problem of overstocking in terms of optimum production per acre is non-existent, and that nothing can be done by scientific investigation further to define the relationship of plants and animals under varying environmental conditions so as to enable more effective use to be made of both. Can it be denied that neither scientist nor producer is equipped with sufficient knowledge of the ecological factors involved in any key pastoral area to decide what system of management, what rates of stocking, or what types of sheep—two small or one large, to quote Stewart—will give the maximum economic return per acre ? There are graziers who ask just these things and who cry in vain for an answer which is not largely speculative.

Stewart assumes further that to speak of better feeding of sheep implies recourse either to pasture improvement or supplementary feeding, neither of which he believes has much relevance to the Merino sheep. In relation to the former, instances could be quoted which indicate that, even in this field, we are guided more by empirical assumption than by scientific fact. What is ignored is that, over large areas of typical Merino country in eastern Australia, better feeding and greater returns, not only per sheep but per acre, can be obtained by a more accurate appraisal of all the factors relevant to efficient plant and animal management.

The unkindest cut of all was to blame the writer for omitting reference to the need for economic research. With the greatest diffidence he would claim that he has urged the necessity for the development of economic research in relation to all branches of the sheep, wool and textile industries with as much vigour as, and to many people with an even more tedious persistence than, any other individual.[2, 3]

## Organization of Research.

It remains to remove one further misconception, namely that there was any intention that all sheep and wool research in the Commonwealth should be concentrated in one laboratory, and that also the one at which textile research was to be centred. The hope was that the scale of current investigations of C.S.I.R., State and other organizations would be greatly intensified, but that, in addition, a central sheep and wool laboratory and a textile research laboratory should be established. It was clearly indicated that both should be under C.S.I.R., if that organization has the heart for and belief in the task.

The sheep and wool laboratory would have responsibility for providing the basic data, physiological, genetic, ecological and metrological, without which local and field observations cannot be fully effective, and for providing experimental material for certain types of textile research. After further consideration and as a result of helpful criticism, the scope of such an institution's activities might be defined as follows : studies on growth and development as these affect characters of economic importance ; physiology in relation to reproduction and adaptation ; controlled production of fleece types for studies in experimental physics and chemistry ;

methods of measurement of fleece and other attributes of importance to the geneticist and field experimentalist ; those aspects of genetics where a controlled environment is necessary ; and to provide a co-ordinating centre from which ecological investigations may be conducted and at which all scientific data pertaining to the sheep under Australian conditions may be collated.

## Conclusions.

It has been demonstrated that the desirability of reducing costs of production in Australia by intensification of biological research is unrelated to the costs of manufacture and distribution of wool textiles. On the other hand, the price of raw wool has a major influence on the cost of finished fabric and on the severity of competition from competitive fibres. The industry cannot afford to remain in ignorance of any character of wool which may affect the purposes for which it is or may be used, or of the means whereby wools possessed of these characters can be most efficiently produced. There is opportunity and need for the extension of biological research equally with textile and economic research into problems of the wool industry.

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# The Preservation of Fruits and Vegetables by Quick Freezing

By

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This brief review of the development of the quick freezing industry in U.S.A. and of the more important problems which the industry has had to face has been attempted because of the firmly established and rapidly increasing importance in that country of quick freezing as a highly satisfactory method of preserving perishable foods and because it is certain that after the war the quick freezing of perishable foods, particularly vegetables and fruits, will be practised extensively in Australia.

The freezing preservation of perishable foods has been practised ever since the advent of artificial refrigeration in the middle of the nineteenth century, but it was not until 1918, when an improved system for the rapid freezing of fish in brine[19] was developed, that quick freezing was born. Since then the technique of freezing foods rapidly has been continually improved and the improvement in quality by freezing quickly has been clearly demonstrated. At the present time in U.S.A. quick freezing is seriously rivalling canning as a means of preserving perishable foods.

Until recently the term " quick freezing " was purely relative, but nowadays the term is usually related specifically to the time in the temperature zone of maximum ice crystal formation. That is, for a product to be quick frozen its temperature must drop during freezing from +32° F. to +25° F. in 30 minutes or less, thus ensuring very small ice crystals and a minimum disturbance of tissue structure.[15] This clearly distinguishes modern quick freezing from the long practised " sharp freezing " in which the product is frozen slowly in still air by placing in a room at low temperatures with the resultant growth of large ice crystals and therefore considerable disruption of the tissues of the product. For quick freezing refrigerant temperatures of the order of −20° F. are generally used, and for satisfactory storage of the quick frozen product temperatures of 0° F. to −5° F. are necessary.

The sharp freezing of berry fruits has been practised in America for more than thirty years, but the quick freezing of fruits was not introduced commercially until about 1930. On the other hand, the freezing preservation of vegetables dates only from 1930. The discovery that inactivation of enzymes in vegetables by scalding or " blanching " prior to freezing will prevent the subsequent development of off-flavours and discoloration[2, 11, 14, 17] and the invention by Birdseye[5] and others[19] of quick freezing systems which permit the freezing of prepackaged products were necessary before satisfactory processes for vegetables could be developed.

Tressler and Evers[19] state that " in general, it may be said that quick freezing preserves the fresh colour, flavour, palatability and nutritive value of fruits and vegetables better than canning or any other method of food preservation known to date ". It preserves almost indefinitely the original quality of the food, converting perishable food to non-perishable food with equal nutritive value.[19] Because frozen foods are already prepared for use, tremendous economies are effected as compared with the distribution of fresh fruit and vegetables. Moreover, the frozen fruits and vegetables are only fifty per cent. of the weight of the canned article in which the product must be fairly loosely filled into a liquid medium for effective heat penetration during processing. Most frozen foods are packed for preference in various types of impregnated paper-board containers with an inner moisture-vapour

proof lining and thus quick freezing in U.S.A. has actually been stimulated during the war because it does not require containers of high priority tin plate.

## Quick Freezing Methods.

*Immersion Freezing.* The rapid freezing of food products has been known for about 100 years, as in 1842 H. Benjamin was granted a British patent on a method of freezing by direct immersion in very cold brine. The first machine to use direct immersion successfully was introduced into the United States in 1918,[19] and since then numerous patents have been granted for methods of freezing in which the liquid refrigerant is in direct contact with the product. Immersion freezing methods are not used very extensively at the present time, but because of their special advantages, principally that of very rapid heat transfer, there will probably be a considerable development of some of the newer processes after the war.

Freezing by Indirect Contact with the Refrigerant. This is an old method, having been used for ice making and the freezing of ice cream for many years. It is commonly used today, the best known example being the Birdseye Multiplate Froster,[5] in which the prepackaged products are frozen by being pressed between hollow metal plates through which the refrigerant is circulated. Birdseye, the pioneer of commercial quick freezing in U.S.A., has recently developed a Gravity Froster for the continuous indirect freezing of loose products.[8]

*Air-Blast Freezing.* Very cold air in rapid motion through an insulated tunnel will also freeze quickly, and tunnel freezing is probably the most commonly used system today. This system is most versatile as products of a wide range of shapes and sizes can be handled in the one plant, but has a serious disadvantage owing to the dehydration of the product during freezing. This difficulty can be overcome largely by freezing in several stages and maintaining a relatively small temperature differential between the refrigerating coils and the air, and by maintaining a high relative humidity in the recirculated air.[19]

*Combination Systems.* An example of these is the freezer which combines plate contact freezing and air-blast freezing, cold air being blown over the packages, which rest on refrigerated plates.

## Quick Freezing and America's Food Supply.

The commercial production of quick frozen foods in U.S.A. has expanded rapidly in recent years, as is shown in Table 1.[21]

TABLE 1.
*Commercial Production of Quick Frozen Foods in U.S.A.*
(Million lb.)

| Year. | Fruit. | Vegetables. | Sea Foods. |
|---|---|---|---|
| 1936 .. .. .. | 70·1[1] | 12·5 | 57·2[2] |
| 1939 .. .. .. | 140·6 | 72·6 | 183·4 |
| 1941 .. .. .. | 207·8 | 107·2 | 246·6 |
| 1943 .. .. .. | 228·5 | 231·0 | 245·6 |

[1] Mainly slow frozen in bulk. [2] West Coast only.

It was estimated that the total U.S.A. commercial pack of quick frozen foods in 1943, including fruits, vegetables, sea foods, poultry and meat, would exceed 1,000 million pounds.[21]

The quick freezing industry is playing a very large part in supplying America's war-time food requirements, and its war-time expansion has been rapid. At the present time the U.S. Armed Forces are using large quantities of quick frozen foods both at home and abroad, and the development of the quick freezing industry has

enabled a very large stock of highly nutritious food to be built up without the use of tin plate containers, which are essential for a wide variety of direct war purposes.

It is probable that after the war as many fruits and vegetables will be preserved by freezing in U.S.A. as will be preserved by canning, and that the proportion of these perishable foods marketed in the fresh state will continue to decrease. A further post-war development will be the quick freezing of fully precooked foods, which will only require warming before consumption, in fact such main course dishes as soups, hash, baked beans and chicken-a-la-king are being quick frozen to a considerable extent at the present time.[1]

## The Freezing of Fruits.

Fruits as a class are the most difficult of all products to freeze without causing radical changes in appearance, texture and colour. Practically all fruits require packing in syrup or with sugar or some other treatment to minimize these dangers.[19] Until last year most of the fruits frozen in America have been berries, strawberries and sour cherries being the most important. In 1943 reduced quantities of berries and cherries and greatly increased quantities of other tree fruits were frozen, as is shown in Table 2.

TABLE 2.
*U.S.A. Frozen Fruit Packs.*[21]
(Million lb.)

| Product. | 1942. | 1943. |
|---|---|---|
| Strawberries .. .. .. | 63·7 | 26·6 |
| Cherries .. .. .. .. | 52·0 | 28·2 |
| Grapes (mainly juice) .. .. | 19·6 | 9·6 |
| Raspberries .. .. .. | 21·7 | 20·7 |
| Apples .. .. .. .. | 15·1 | 33·8 |
| Peaches .. .. .. .. | 14·2 | 21·6 |
| Apricots .. .. .. .. | 5·3 | 19·9 |
| Plums and Prunes .. .. | 3·0 | 25·3 |
| Other .. .. .. .. | 27·3 | 42·9 |

*Optimum Maturity.* It is of very great importance that fruit for freezing be picked in prime eating ripe condition, that is, in general, the fruit should be riper than for canning. Immature fruit when frozen and thawed is usually very sour, often very bitter, lacking in colour and flavour, poor in texture and often badly discoloured.[19] Over-ripe fruit becomes even more mushy, is very difficult to handle and usually develops off-flavours during preparation for freezing.[19] Uniformity of maturity is of considerable importance ; this may require frequent picking, frequent sortings or the discarding of unripe portions of fruits which ripen unevenly.

*Adaptability of Varieties.* The rating of varieties for freezing is a difficult matter because the behaviour of a given variety during freezing is considerably affected by climate, soil and cultural practices. Furthermore, a variety which freezes well may be unsatisfactory commercially because of low, uneconomic yield or susceptibility to diseases or pests. Consequently considerable work has been done in U.S.A. on the evaluation, selection and breeding of varieties of fruits for quick freezing.[19] For example, the varietal adaptability of peaches has been studied extensively,[19] but there is little agreement between workers at different centres as to which varieties are best. Best results have generally been obtained with the yellow fleshed freestone varieties, in particular Hale Haven, South Haven and J. H. Hale.[19] Elberta is frozen commercially to a considerable extent because it is produced in large quantities, but it requires very careful handling as it develops a brown colour very readily on exposure to air. Taking strawberries as a further example, the best variety for

freezing depends very considerably on the locality where it is grown ; thus the Marshall variety is the principal one in the Pacific North-West, whereas Klondike is the chief variety in North Carolina and Louisiana.

*Difficulties with Fruit.*

(*a*) *Browning.* Many fruits, particularly most varieties of peaches, cherries and apples, darken rapidly after peeling or cutting. This reaction is largely the enzymic oxidation of the catechol-tannins which these fruits contain and proceeds in the presence of air, even during frozen storage.[19] The degree of browning which develops at all stages, particularly during thawing, is a most important factor in the selection of varieties suitable for freezing.

(*b*) *Loss of Flavour.* Fruits lose flavour rather rapidly after cutting or peeling and many fruits develop off-flavours. These changes, which are also oxidative, are particularly prone to occur during exposure to the air in the course of preparation for freezing and in final thawing for use.

(*c*) *Loss of Texture.* This is a serious problem and results in flabbiness and leakage after thawing. It is due principally to the following three effects[22] :

(i) During freezing most of the water crystallizes as ice, principally in the intercellular spaces and the ice crystals puncture cells. With increasing speed of freezing the ice crystals become smaller and damage from this cause is reduced. The ice crystals grow in storage, particularly if the storage temperatures fluctuate, thus causing more mechanical damage. Therefore, the storage temperature should be as constant as possible.

(ii) Flabbiness may be due to the withdrawal, during freezing, of more water from the cells to the intercellular spaces than is reabsorbed on thawing, even though no cell walls are broken.

(iii) Freezing tends seriously to destroy the colloidal complex of the cell contents, and thus reduces turgidity.

## The Freezing of Vegetables.

According to Tressler and Evers,[19] and from American commercial experience, freezing preservation, properly carried out, comes very close to preserving the natural fresh flavour of most vegetables and is superior to canning. In general, vegetables which are commonly cooked before being eaten can be preserved very well by quick freezing and the following yield attractive products : peas, lima beans, sweet corn, broccoli, asparagus, snap beans, spinach, carrots, squash, turnips, kohl-rabi, Brussels sprouts, beetroot and cauliflower.[19]

Cabbages, potatoes, onions and pumpkins are the principal exceptions amongst those usually eaten cooked, and satisfactory methods for preserving these and salad vegetables have yet to be worked out.[19] Salad vegetables are desirable largely because of their crispness, which is lost during freezing. Vegetables are almost invariably prepared for cooking before freezing.

TABLE 3.
*U.S.A. Frozen Vegetable Packs.*[21]
(Million lb.)

| Product. | 1942. | 1943. |
|---|---|---|
| Peas .. .. .. .. | 66·2 | 72·2 |
| Lima beans .. .. .. | 30·4 | 23·7 |
| Spinach .. .. .. .. | 16·6 | 29·7 |
| Snap beans .. .. .. | 13·9 | 26·5 |
| Corn .. .. .. .. | 13·3 | 21·5 |
| Others .. .. .. .. | 22·2 | 57·6 |

The figures in Table 3 show that peas are the most important vegetable for freezing ; this is principally because peas are an important mechanized crop and because the quality of frozen peas is very superior to that of the canned product.

*Optimum Maturity.* The maturity at which vegetables are harvested and the extent of changes between harvesting and freezing are of critical importance in determining the quality of quick frozen vegetables. The vegetables must be harvested right at the time of highest quality and frozen as soon as possible to keep post-harvesting changes at a minimum. For example, peas should be young, sweet and tender, but to ensure uniform maturity and therefore quality, it is usual to quality grade the shelled peas by flotation in brine before freezing.

*Difficulties with Vegetables.*

One of the biggest difficulties is control over the quality of the raw material. This is affected chiefly by variety, maturity, climate and soil, cultural practices and delay after harvesting. This latter point is of critical importance and vegetables must be frozen within a few hours of harvesting to ensure the final high quality upon which success in the quick freezing industry so largely depends. Deterioration after harvesting is particularly rapid in the case of peas, sweet corn, lima beans and asparagus.[19] It has been shown that peas lose approximately one-third of their sugar if held for six hours after picking at 77° F.[12] Vined peas and lima beans deteriorate very rapidly because of the bruising they receive during vining.[13] As in the case of fruits, freezing and thawing cause a wilting of vegetable tissues, and desiccation during storage is a problem which necessitates the use of moisture-vapour-proof packages.

*Blanching.* Scalding or blanching is the most important operation in the preparation of vegetables for freezing ; it must be rapidly and carefully done and the vegetables must be rapidly and effectively cooled immediately after heating. Until 1928 it was believed that freezing ruined vegetables. Early experiments on the freezing preservation of vegetables were not successful because of the rapid development of hay-like off-flavours and discoloration after freezing. In 1929 Joslyn and Cruess[11] in America and Barker[2] in England came to the conclusion that it was essential to scald or blanch vegetables before freezing. It has been shown since by many investigators that blanching not only retards undesirable changes before freezing, but inhibits the development of off-flavours during storage and thawing, fixes the green colour and considerably improves the general keeping qualities of the frozen product.[10, 18, 19] Blanching should be carried out by heating in steam or in boiling water and should only be continued long enough to inactivate the enzyme per-oxidase.

*Adaptability of Varieties.* As with fruits, the selection of varieties depends considerably on the climate and the soil where the vegetables are grown. Varieties best for canning are not necessarily best for freezing, in fact the reverse is often the case, and it has been necessary to select and develop varieties of vegetables specially for freezing preservation.[19] This has been specially true in the case of peas.[19] Considerable varietal work has been done with sweet corn[19] and has resulted, for instance, in the development of Tendermost Bantam,[16] a variety which yields well and which fulfils very well the specialized high quality requirements for freezing.

## General Considerations.

*Microbiology of Frozen Foods.*

Many micro-organisms will grow at or below freezing point, some moulds such as *Cladosporium* and *Sporotrichum* are not inhibited at 20° F. and *Mycoderma* will increase at this temperature. At 15° F. all microbial growth in fruits and vegetables is arrested completely and quick freezing and frozen storage reduce very considerably the numbers of viable micro-organisms in the product.[3] Fears that quick

frozen foods are not bacteriologically safe because some harmful bacteria resist freezing storage are unfounded. The American public has been consuming quick frozen foods for more than ten years without trouble from food-borne diseases. It has been demonstrated conclusively that frozen foods after thawing will spoil rapidly and become quite inedible before they become bacteriologically dangerous to the consumer.[4]

*Packaging Problems.*

These are of very great importance and although there is little agreement between commercial packers as to the best type of package there are certain points which must be considered. The package must be strong, cheap, attractive and suitable for use with automatic equipment. It must largely prevent access of outside air to minimize enzymic and chemical changes. Its materials must be odourless, tasteless and non-toxic. It must be moisture-vapour proof to minimize desiccation and in many instances must be water-proof.[19]

Tin cans and glass containers fulfil these requirements but there is the very strong practical objection that they are definitely associated with preservation without refrigeration. Therefore the development of completely different containers was commenced and now the paper-board base container, although not fully satisfactory, has reached a high stage of efficiency and is definitely associated with frozen foods by the consumer. The standard container now is a waxed paper-board rectangular carton with an inner moisture-proof liner or bag, usually of moisture-proof cellophane but sometimes of special water-proof parchment or waxed paper and with an outer protecting cover often again consisting of cellophane or heavy waxed paper. Transparent rubber-derivative film, such as Pliofilm, is rapidly coming into use as the ideal inner bag material for frozen foods, being moisture-proof, moisture-vapour-proof and to a considerable extent gas-proof.[19]

*Storage Problems.*

The proper storage temperature is a vital point in the storage of frozen foods. Initially it was thought that temperatures of 15-20° F., which were used for the freezing and storage of fish, would be satisfactory, but it was soon found that the storage life and quality of frozen foods stored at these temperatures were much inferior to those of products stored below +5° F. Now all quick frozen products are stored at 0° F. to −10° F., 0° F. being quite satisfactory for most products.

It is essential that the storage temperature should be constant. Even small fluctuations in temperature will cause continued growth of ice crystals, thus increasing internal mechanical damage and desiccation.[22] To minimize desiccation, which is an important cause of loss of quality, moisture-vapour proof packaging materials should be used. It is also necessary to maintain a high humidity in the storage room and a further very useful precaution is to ice or syrup glaze the produce during or immediately after freezing.

*Transport Problems.*

During transport it is important to maintain a constant low temperature as near as possible to the original storage temperature, and at all costs to prevent any thawing out of the product. Partial thawing with subsequent slow freezing is extremely detrimental.[19]

The development of the railway refrigerator car and of refrigerated motor transport have been of vital importance to the quick freezing industry. Frozen foods and the shipping cases in which they are packed should be at a temperature of 0° F. or lower when placed in the refrigerated transport vehicle, and this temperature should be maintained as closely as possible. The problem of maintaining a temperature of 0° F. during transport for periods up to several days raised many

problems concerning methods of refrigeration and insulation. Refrigerator cars and refrigerated motor trucks have been brought to a high state of efficiency in America and at the present time are used in large numbers. In addition to these, small insulated shipping containers have been developed for shipping as ordinary freight. If they are required to hold the temperature for more than 24 hours, solid carbon dioxide is packed with the frozen products.

*Marketing Problems.*

The distribution and marketing of frozen products have been a major problem since the beginning of the industry and although quick frozen foods are now nationally known and distributed, the merchandising side of the industry is still full of difficulties. Most of the failures in the quick freezing industry have been due to problems in retail distribution,[19] and it was not until the General Foods Corporation started to freeze a variety of foods and equip a number of retail stores with suitable low temperature storage display cabinets that retail distribution was successfully established. However, even today wholesale distribution of bulk packs offers the best possibilities for the small producer of quick frozen foods.[19] Today in America many restaurants and hotels use frozen foods almost exclusively because of their reliability and ease of preparation.

The main problems in the development of frozen food distribution can be summarized as follows :

(1) Retailer and consumer resistance to entirely new lines, requiring extensive expenditure on advertising and education.

(2) The necessity for organized provision of satisfactory retail storage-display cabinets.

(3) The maintenance of quality consistent with reasonsble cost to the consumer.

*Refrigerated Locker Plants and Farm and Home Freezers.*

The rapid expansion of freezer-locker plants in America for the preservation of fruits, vegetables, meat and fish is an outstanding development in food distribution.[9, 20] According to a survey by the Farm Credit Administration[20] early in 1943 approximately seven million people were then served by thousands of refrigerated locker plants in various parts of the country. The refrigerated locker plant may be described as a safe deposit box at 0° F. where rural or urban consumers and small producers may safely store supplies of perishable foods which have been grown at home or purchased wholesale.[19]

A very recent development in America[19] for which big post-war plans are being made is the manufacture of small farm-size combination cool storage and quick freezing units. Trials before the war stopped their production indicated that these units would be widely accepted in rural districts. Household freezing and storage of quick frozen foods is being provided for by manufacturers.

These developments undoubtedly will expand greatly the application of quick freezing to the preservation and distribution of perishable foods.

## Quick Freezing in Australia after the War.

A quick freezing plant will shortly be in operation in Sydney and will freeze appreciable quantities of vegetables to meet special service requirements. Plans are being developed by commercial food processing firms for the commencement of quick freezing on a big scale as soon as conditions permit and it is certain that the quick freezing industry will become established firmly in Australia after the war. In this connection an immediate research task will be to investigate the suitability for freezing preservation of Australian varieties of fruits and vegetables and to investigate the effects of our tremendous variations in climate and soil on their quality and on the quality of varieties found to be suitable in U.S.A.

It must be realized clearly that the key to the successful establishment and continued expansion of quick freezing is quality control. Popular acceptance of quick frozen foods will depend very largely on the continued presentation of products of superior quality. The maintenance of this high quality starts in the field and demands continued vigilance at all stages from harvesting of the raw material to the final sale of the product.

In the post-war period there will be keen competition for restricted markets for fruit and vegetables, and there is an increasing realization that quality control will be essential for success in the developing quick freezing industry, in the canning of fruit and vegetables and also in the marketing of fresh produce.

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# The Function of Mineral Elements in Plant Nutrition

By

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A full appreciation of the value and use of inorganic fertilizers in agriculture is impossible without an understanding of the rôles played by the various mineral elements in the metabolism and as structural components of the plant. Our knowledge of these functions is as yet very incomplete and much still remains to be learned about the biochemical aspects of plant growth, although increasing attention is being given to this type of plant physiological research.

This article attempts to summarize briefly the present state of knowledge of the functions of those mineral elements known to be essential for plant growth. Constant reference to Figure 1, in which are shown some of the more important metabolic processes, will assist in following the text. This diagram has been compiled chiefly from reviews on nitrogen metabolism,[4, 17, 20] carbohydrate metabolism,[18, 31] organic acid synthesis,[3] and from a discussion of nitrogen and potassium in carbohydrate and nitrogen metabolism.[12]

The matter to be presented has in general been compiled from experiments in which more than one factor has been studied at several levels. Experiments which have attempted to study the rôle of specific elements by a comparison of the metabolism of deficient with excess plants, especially at one point of time, have been avoided as far as possible. It is clearly desirable in all work of this nature to avoid confusion of effects due to excess of any element with effects of a deficient element. It is also necessary to study all the chief metabolic processes, especially in a preliminary survey, as an upset in one particular reaction may cause disturbances throughout a whole series of reactions. For example, if the assimilation rate is low, lack of carbohydrate may limit the amount of proteins formed and lead to an accumulation of nitrates and ammonia-nitrogen; thus in a study in which only nitrogen fractions were determined, the effect of influencing the formation of amino acids may be ascribed to an element, whereas in reality it is limiting a photosynthetic process.

## Nitrogen.

The importance of proteins in plants has long been recognized and the chain of processes by which these are synthesized from inorganic substances has been studied intensively. It would be far beyond the scope of this paper to discuss the many aspects of this subject; the reviews of Chibnall,[4] Petrie,[20] and Nightingale[17] should be consulted in this regard. The more important processes are outlined on the left-hand side of Figure 1.

It may be pointed out here that the level of nitrogen in the plant influences the nitrogen cycle only in its intensity, and apparently exerts no influence on its qualitative course. There is little indication of departure in nitrogen-deficient plants from the usual protein cycle, the observed fractions bearing much the same relation to one another as in high-nitrogen plants.[25] The low level of proteins, however, restrict meristematic activity and lead to stunted plants. There is an accumulation of total sugars, resulting from the check in protein synthesis. Despite this accumulation of sugar, the rate of respiration is greatly decreased. Gregory and Sen[12] have attributed this to a low rate of protein synthesis and breakdown. They observed a very close parallel between the levels of respiration and of nitrogen metabolism

and this relationship was independent of carbohydrate supply. It would appear that even if carbohydrate is the main respiratory substrate in plants, there is a general regulation closely associated with protein synthesis and breakdown, and thus with nitrogen level, which controls the whole process.

It is possible that respiration and other processes may be influenced indirectly by nitrogen deficiency through an effect on enzyme synthesis. Many, if not all, enzymes contain protein groups. It is not clear to what extent any level of nitrogen affects the formation and functioning of these catalytic agents. Is there sufficient nitrogen supplied by the seed or by very low levels of nitrogen in the substrate for the synthesis of the entire enzyme requirements of plants, or is the supply for this purpose limited in low nitrogen plants? It is true that a deficiency of nitrogen retards the formation of chlorophyll, as shown by the pale-green colour of nitrogen-deficient plants. Whether enzymes required in smaller amounts are equally reduced is not known. These and many other aspects await further investigations on the chemistry and dynamics of plant enzyme systems. Valuable information will no doubt also be obtained from studies on the protein metabolism of virus-inefcted plants.

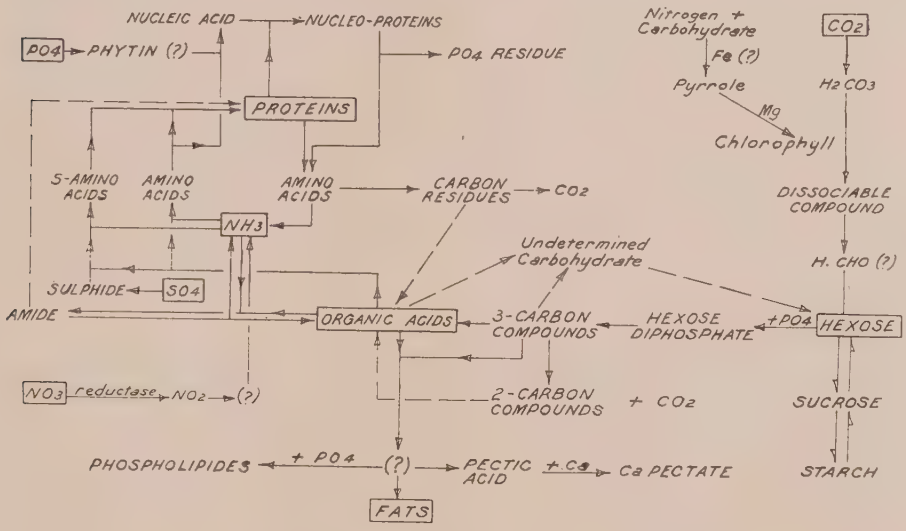


*Figure* 1.
Diagram showing relationships between the chief metabolic processes in plants. (Continuous lines indicate established reactions; broken lines, probable reactions.)

Frequently, high nitrogen levels in the soil solution coupled with proportionately low carbohydrate assimilation give rise to plants which have high concentrations of nitrates and ammonia-nitrogen. This is common in northern European countries, where photosynthesis is limited by low light conditions. In these cases, leguminous plants may excrete nitrogen fixed by the symbiotic bacteria into the soil in the form of β-alanine.[33] Usually, however, there is no loss of nitrogen from the plant, and the accumulation of nitrates and ammonia-nitrogen may result in pathological symptoms.

## Phosphorus.

One of the characteristic features of phosphorus in plants is its effect on nitrogen metabolism. A lack of phosphorus appears to check the synthesis of proteins

beyond the stage of amino-acid production, resulting in a marked accumulation of amino-acids, ammonia-nitrogen and nitrates. Eckerson[7] has attributed the accumulation of nitrates in low-phosphorus plants to a direct effect of phosphate on the activity of the enzyme reductase, which catalyses the reduction of nitrate to nitrite. The check in nitrate reduction, however, is more likely to be a mass action effect resulting from the accumulation of amino-acids.[25]

It has long been known that phosphorus is a constituent of nucleic acid and nucleo-proteins, but it now appears that this element is necessary, if not as a component then as an agent, for the formation of many, if not all, of the simpler proteins.[25] It may be remarked that phytin (an acid calcium magnesium salt of inosite phosphoric acid) has been isolated from plants in fairly large quantities at various periods of their growth. There is an inverse relation between phytin and protein in developing seeds.[5, 15] It is possible that this substance may be a precursor of either nucleo- or phospho-proteins, or perhaps intimately concerned in the synthesis of all proteins.

The respiration rate is greatly reduced with extreme deficiency of phosphorus.[23] This appears to result from the lack of sufficient phosphate for the breakdown of hexoses (see Figure 1). At intermediate stages of phosphate deficiency and in fully-manured plants, respiration is closely related to the concentration of proteins and amino-acids, but not with reducing sugar ; while with extreme phosphate deficiency, it depends on the level of reducing sugar. It has been shown that the content of reducing sugar which is limiting respiration in phosphate-deficient plants is as high as that of high-phosphate plants ; yet with high phosphate supply, the same sugar concentration not only accompanies a much higher respiration rate, but exerts no detectable limitation on that rate.[23] This may be explained in the following way. With extreme deficiency, the concentration of hexose diphosphate is greatly reduced. The rate of supply of triose respiratory substrate will be roughly proportional to the hexose concentration, if the phosphate in the hexose phosphate cycle tends to a fairly constant low level. At high phosphorus levels, the supply is sufficient to meet all normal demands and reducing sugar bears no relation to respiration rate.

Photosynthesis is not affected by a moderate degree of phosphate deficiency but is decreased by extreme deficiency.[9, 10] It is likely that this decrease is directly related to the accumulation of carbohydrates resulting from decreased respiration and protein synthesis rather than to any specific effect of phosphorus on the photosynthetic reactions.

Phosphorus is a constituent of phospholipides and therefore is connected intimately with the fat metabolism of the plant, but little information is available concerning this metabolism and the possible relation of phosphorus to it.

## Potassium.

The exact function of potassium in the plant is still very uncertain. It does not appear to be a structural element of any organic compound and it is usually present in a very soluble and mobile form. Elucidation of its exact function is made very difficult by the modifications in the type and metabolism of potassium-deficient plants caused by different levels of calcium and sodium and possibly other elements. There is evidence which suggests that sodium is able to replace potassium in some of the reactions with which the latter is usually associated.

Many investigations have been made on the metabolism of potassium-deficient plants, but the effects noted have been as varied as the external conditions under which the experiments have been conducted. In general, it may be said that a deficiency of potassium leads to rapid proteolysis, resulting in a marked accumulation of amides and amino acids,[12] and is accompanied by a high respiration rate. Potassium does not appear to be necessary for protein synthesis ; rather, in its

absence, the breakdown of proteins is greatly increased. This effect possibly represents what may be one of the most important functions of potassium : its vital concern in some physico-chemical relation which is necessary for the " maintenance of the protoplasmic complex ". This may be related to one or several particular buffer systems in the plants ; Hoagland,[13] for instance, ascribes particular importance to potassium in such systems. Although it is known that some enzyme systems are influenced both by hydrogen-ion concentration and by the buffer employed *in vitro*, little is known of plant enzyme systems or the effect of surrounding conditions on them.

Potassium-deficient plants are also characterized by a low sugar content, an effect which appears to be a direct consequence of a low assimilation rate. It has been suggested frequently that potassium is necessary for the transport of carbon dioxide to the reactive chloroplast surface and the low assimilation rate has been ascribed to this function. It would be thought that sodium could replace potassium in this reaction, but potassium-deficient plants high in sodium also show a low rate of assimilation.[11] Although there is much evidence to show that potassium does influence the level of photosynthesis, the low sugar content of potassium-deficient plants may also be explained by a decrease in their amylolytic activity, resulting in a high proportion of starch to sugars.[32] This would greatly influence the carbohydrate and protein metabolism, but does not explain the high respiration rate. A reduction in the amount of substrate should reduce the rate of respiration, unless as appears probable the increased rate of carbon dioxide output is a direct consequence of protein degradation.

Potassium then is concerned with three important metabolic processes at least : the breakdown of proteins, the assimilation of sugars and the hydrolysis of starch to sugar. In these three processes, its function appears to be physico-chemical in nature rather than chemical, and it is possibly related to some effect on the enzyme systems concerned.

## Sodium.

Sodium has not been proved to be essential for the growth of plants ; nevertheless, the fact that it appears to be a partial substitute for potassium suggests that normally it may be concerned in some plant processes. If this is so, its effect is likely to be of a physical or physico-chemical nature. Its high correlation with water content[24] is suggestive in this regard. Rohde[26] has recently summarized much of the literature on the relationship between sodium and potassium in plant metabolism.

## Calcium.

Calcium is precipitated in the walls of plant cells as calcium pectate, a substance which appears to be necessary for the maintenance of cell rigidity and for the prevention of leaching of ions from the cells.[30] Calcium appears to be involved in the metabolism of fats and associated with boron in this regard, but the data are not sufficient to indicate the exact reactions with which it is concerned, or whether the effects noted are not more directly associated with other aspects of carbohydrate metabolism.

The occurrence of calcium oxalate in many cells has led to the somewhat teleological suggestion that calcium is necessary for the neutralization of organic acids.[19] There is no evidence to indicate that excess organic acids are harmful ; indeed they are an important intermediate stage between carbohydrate and nitrogen metabolism. The formation of calcium oxalate may well be an accidental consequence of the presence in the cell of both soluble calcium salts and of organic acids. Dunne[5] has suggested that oxalic acid is synthesized in part as a result of calcium absorbed by the plant, in view of the higher oxalic acid content in high-calcium

than in low-calcium plants. Other workers have obtained similar results, but attribute the accumulation of acid to a retardation of the breakdown of acids to simpler substances by an effect of calcium on the enzymes concerned.[26] The relationship of organic acids to nitrogen-metabolism should not be overlooked since calcium, as a constituent of phytin, may be involved in the formation of nucleic acid and possibly other proteins.

### Magnesium.

Magnesium is a component of chlorophyll and is therefore essential for photosynthesis. It is also probably associated with other enzyme systems in the plant. It appears to be essential for the formation of nucleoproteins (perhaps through phytin) and to act as a carrier of phosphorus in the formation of phospholipides, but the enzyme systems concerned have not been isolated.

### Iron.

Iron is essential for the formation of chlorophyll but its exact relation to this substance has not yet been fully established. There is some evidence that it has a catalytic effect in the formation of the pyrrole nucleus of chlorophyll since it was found that the production of chlorophyll occurred in plants grown in solutions devoid of iron but containing magnesium pyrrole salts.[21] Other investigators, however, have failed to confirm this work.[2]

The cytochrome complex, catalase, and peroxidase all contain iron in their prosthetic groups, and it is likely that there are other enzymes containing iron-protein groups. Iron is therefore extremely important in the respiratory reactions which are catalysed by these enzymes.

### Sulphur.

As a component of proteins, sulphur plays an essential part in plant metabolism. The essential reactions involved are indicated on the left-hand side of Figure 1. As in the case of nitrogen metabolism the complete course of sulphur metabolism has not yet been investigated fully (see Wood and Barrien[34]). The derivatives of sulphur amino acids or proteins—glutathione and cystein—enter into the formation of enzyme systems, such as cytochrome, and are themselves important as hydrogen-carriers in the cell. The pale-green to yellow colour of sulphur-deficient plants suggests that sulphur is necessary for the formation of chlorophyll. Excess barium or strontium may sometimes cause sulphur deficiency in plants by precipitation of the insoluble sulphates.

### Copper.

The essential nature of copper for plant growth, as indicated by the failure of plants to grow in a copper-deficient medium, is no doubt connected with the rôle of copper as a constituent of certain enzymes. Two groups of enzymes which are copper proteins have been isolated in plants—(i) those that oxidize mono- or polyphenols, such as polyphenol oxidase, and are therefore concerned in some respiratory processes, (ii) those that oxidize ascorbic acid, such as ascorbic acid oxidase.

### Manganese.

Although it has been proved that manganese is essential for growth, the function of this element has not been established. In common with most of the heavy metals, it may serve as a catalyst, but whether it actively catalyses a reaction itself, acts as an activator of an enzyme system, or is a constituent of an enzyme molecule is unknown. Apart from its action in actively catalysing the cozymase system, little else is known of its function. An interesting relationship with iron has been shown.[29]

It appears that a proper balance of both iron and manganese is required for healthy growth. When one is low in relation to the other, pathological symptoms appear. It should be noted that symptoms of iron deficiency are similar to those of manganese toxicity and *vice versa*. It is suggested that manganese having a higher oxidizing potential than iron tends to oxidize the metabolically active ferrous ions to ferric ions, which are precipitated as a ferric phosphate organic complex. Usually the iron is retained in the active ferrous condition in the cell by the reducing systems and if present in excess may cause pathological symptoms. The presence of an oxidizing agent such as manganese will overcome this tendency by inactivating some of the iron. The theory that manganese acts as an oxidant of iron in a manner similar to that suggested above is supported by the fact that cobalt, which has a higher oxidation potential than manganese, is more effective than manganese in reducing the soluble iron content of plants. It is of course not suggested that cobalt can replace manganese, because it appears that the latter is also concerned in other reactions. As the reactive form of copper in plants occurs as cuprous ions, a similar relationship between copper and manganese as between iron and manganese may exist.

## Zinc.

The function of zinc in metabolism appears to be connected with some oxidation-reduction mechanism of the cell. For instance, it is required for the maintenance of auxin in an active state in cells, but not for its synthesis.[7,8] Zinc-deficient plants are low in auxin, but indole-3-acetic acid will not replace zinc. Furthermore, this hormone is inactivated more rapidly by zinc-deficient than by high-zinc plants. It appears that zinc acts with some oxidation-reduction system ; when zinc is deficient, the oxidation capacity increases and auxin is destroyed. This is supported by the frequent occurrence of catechol inclusions in the cells of zinc-deficient plants. These coacervates are apparently formed by oxidation of phenolic compounds. The oxidation of phenols is prevented by the active presence of hydrogen-donators, such as the dehydroascorbic or dehydroxyascorbic acid systems, or by thiol-containing groups such as glutathione or cystein. It is likely that zinc is connected with these hydrogen-donators in some manner ; for example, the formation of a zinc-cystein complex has recently been shown.[22] Work on nutrition of the fungi has shown that zinc accelerates the destruction of sugars and other oxidizing processes.[8] It has also been found that zinc accelerates the transformation of methyl glyoxal to lactic acid *in vitro*.

It has been suggested that one way in which zinc may increase the oxidation capacity of plant cells is by inactivation of some parts of the reducing system. It may also enter into the formation of specific enzymes as Keilin and Mann[19] have isolated a zinc-protein system from blood corpuscles which catalyses the reaction $H_2CO_3 \rightleftarrows CO_2 + H_2O$. Although there is no proof of such a system in plants, it may function in some of the respiratory or assimilation processes. It also suggests that other enzymes may consist of zinc-protein groups. A third possible rôle of zinc is as a specific catalyst of some reactions.

## Boron.

Although boron has received more attention than any other trace element, there is as yet no indication of its function in plant metabolism. It is generally agreed that it has a close association with calcium and may possibly be concerned with some aspect of fat metabolism.[16] It has also been suggested that boron may be associated with protein synthesis[27] ; this is supported by the observation that it is essential for the development of nitrogen-fixing bacteria on the roots of legumes. There is an entire lack of any evidence, however, which indicates any of the specific functions with which boron is associated.

## Molybdenum.

Molybdenum has been shown to be essential for the growth of higher plants[1] and of fungi,[8] but few investigations have been made on its possible rôle in metabolism. It may be said that this element is related to the nitrogen metabolism of *Aspergillus niger* and is essential for nitrogen fixation by *Azotobacter* and by *Rhizobium*.

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# TECHNICAL NOTE

## PHOMA STEM DISEASE OF FLAX.

In December, 1942, a severe type of stem spotting occurred on a small percentage of plants in a mature crop of Concurrent flax grown at Leongatha, Victoria.

In appearance the disease somewhat resembled "Pasmo", particularly as numerous pycnidia occurred in the lesions. The spots occurred on any part of the stem and were dark brown in colour, often with a lighter coloured centre, elongated, and usually completely encircled the stem (Fig. 1). In some plants the upper half of the stem had been killed. In other instances the stems had evidently been weakened at the site of the lesion as a sharp bend occurred at this point, giving the affected plant an appearance similar to that caused by hail damage. The bases of affected plants usually appeared quite normal.

*Figure* 1.
Phoma stem disease of flax.

An examination of the pycnidia occurring in the diseased areas showed them to be those of *Phoma* sp. This fungus was readily isolated from the lesions. The pycnidia were sub-epidermal, dark, spherical, ostiolate, 96-130 μ in diameter, ostioles round 17 to 21 μ, average 19 μ in diameter. The spores were hyaline, unicellular, elliptical, variable in size from 2·1 to 17·3 μ by 0·9 to 6·9 μ, average 6·5 by 2·2 μ.

The dimensions given above do not entirely agree with those of any of the species of *Phoma* recorded on flax. However, while the range in size is greater, the average spore measurements of the Leongatha fungus are close to those of *P. exigua*.[5, 6] *P. linicola* has, on the average, larger pycnidia and spores.[2, 3]

Although the disease at Leongatha was of only minor importance, it was of some interest as the symptoms shown by the plants were apparently not those usually described on flax plants affected with *Phoma* spp. Pethybridge *et al.*[4] attributed a foot rot disease of flax to *Phoma* sp. This fungus was later named *P. linicola* by Marchal and Verplancke.[2] The symptoms were described as a severe rotting at the base of the stem causing premature death of the plant. Naoumoff[3] obtained the same fungus from the middle and apical portions of flax stems, which, however, were never killed or discoloured. Similarly De Jonge[1] found that the "dooden harrel" disease of flax in Holland and Belgium was associated with *Phoma exigua*.

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# The Australian Institute of Agricultural Science

## MEETING OF COUNCIL.

A meeting of Council was held at the School of Agriculture, Melbourne University, on 10th July, 1944. *Present.*—Mr. R. A. Boyle (V.), in chair, Dr. A. E. V. Richardson (S.A.), Dr. H. C. Forster (W.A.), Mr. J. L. Provan (Q.), Mr. R. W. Prunster (A.C.T.), Mr. G. H. Vasey (N.S.W.), Mr. F. S. Crawford (T.), and the Hon. Secretary, Mr. A. J. Vasey.

Preliminary reports were received from most delegates as to the present position in their respective States on returned soldier preference.

It has been decided that a full general meeting with agenda to provide for technical discussions shall be held over a period of three days in February, 1945. Representation of each Branch at such a meeting is very desirable and, if it is necessary to ensure this, the fares and expenses of one delegate from each Branch shall be paid by the Institute. An appropriation not to exceed £150 was approved for the expenses of the general meeting including the estimated expenses of delegates.

The proposal to bring the previous report on status and salaries of members of the Institute up to date was approved and Dr. Forster and Mr. Vasey were appointed to proceed with this work. The document is to be prepared for submission to the Rural Reconstruction Commission, and in a form suitable for submission to employing authorities. In addition to stating the present position it shall include a salary scale considered appropriate for the payment of Institute members throughout Australia.

It was agreed that the Office of Management of the Institute should be transferred to Sydney as from the end of the year 1944 and that the N.S.W. Branch should nominate an Honorary General Secretary and Honorary General Treasurer. The present office-bearers will continue in office until after the general meeting in February.

The following applicants were admitted to membership: P. Vaidyanathan, N. R. Wills, J. Douglass (N.S.W.), I. P. Bonnerup (W.A.), P. T. Mitchell (Vic.), R. C. Cannon (Qld.).

The resignation of Dr. N. S. Noble from the position of Business Manager of the Journal, after seven years' service, was accepted with regret, and Council's appreciation of his services was expressed. Dr. Noble's report on Volume 9 of the Journal was received and will be published in next issue of the Journal. After consultation with the Publications Committee, the N.S.W. Branch nominated Mr. N. C. Lloyd to succeed Dr. N. S. Noble. Mr. Lloyd was appointed to the position by Council, his duties commencing with Volume 10, No. 3.

Dr. Richardson (S.A.) expressed the view that the release from the Army of agricultural students, who enlisted early in the war when part way through their University courses and before the present control of scientific personnel, should be brought to the attention of the Director of Scientific Personnel, stressing the Army service they had already given and the short period required to complete their training.

## MEETINGS OF BRANCHES.

### New South Wales Branch.

At a large meeting of the Branch held on 9th June, the main business was an address by Dr. L. V. Burton on the World Food Situation, with special reference to Post-war Europe. A summary of the address is given under Current Notes and News in this issue of the Journal.

The subject of a meeting held on 11th August was Agricultural Surveys as a Basis for Land Settlement, at which addresses were given by Mr. W. J. K. Taylor, Deputy Chief of the Division of Soils, C.S.I.R., and Mr. M. J. Cronin, Assistant Under Secretary of the N.S.W. Department of Lands and member of the N.S.W. Closer Settlement Advisory Board. Mr. Taylor discussed various aspects of surveys for potential land use, the main points of which are given in his contribution to this Journal, March, 1944. Mr. Cronin outlined difficulties in the administration of closer settlement schemes which originated after the last war, and indicated that it is now realized that extensive soil surveys and other investigations of a technical nature should precede the future development of repatriation and closer settlement schemes.

### Queensland Branch.

At a meeting of the Queensland Branch on 17th May, Mr. Colin Clark, Director of the Queensland Bureau of Industry, delivered an address on "The Economic Relationships between City and Country".

Mr. Clark traced the relationship between urban and rural populations throughout historical times, and pointed out that there was a general, although not uniform, tendency for the relative numbers engaged in rural pursuits to diminish. At present the ratio of agricultural to total

population differs greatly in different parts of the world. It is highest in China, Java and Siam, with about 80 per cent.; Australia has 25 per cent. (Queensland 30 per cent.) and Great Britain is at the bottom of the scale with six per cent. A high percentage of rural population is usually associated with comparative poverty and a low standard of living; it is a simple economic law that as the wealth of a community increases the proportion of income spent on primary products diminishes. Other determining factors are the extent to which the country imports and exports, and the productivity of the agricultural worker. Secondary industries are subject to the same economic laws as primary industries, as are also the tertiary—commerce, education, administratve, transport, post office, etc. In any wealthy country tertiary production is the most important form of economic activity.

The speaker then passed on to the subject of the probable or desirable development of cities n Queensland, and discussed figures compiled for the Queensland Employment Exchange,, Districts. They show that the most sparsely populated districts have the highest population of agricultural workers due to the fact that the money is mostly spent outside the district. In discussing the future of country towns, Mr. Clark expressed the view that the population of the State should be distributed in 20–30 regional centres of urban growth. Larger cities have many disadvantages and it is now agreed that 150,000 is the optimum size from the commercial and social points of view. The city should be in economic equilibrium with its hinterland of rural population.

The address was on a topic now exercising the minds of many thinking agricultural men, and a keen discussion followed, Mr. Clark suggesting that tariff protection, distribution of government contracts, control of freights, improvement of education facilities and decentralization of the State Public Service might help to give a better distribution of population.

The meeting of the Branch on 7th July, 1944, was addressed by Mr. A. R. Trist, Officer in Charge of the Silvicultural Section of the Forestry Sub-Department, on various aspects of Forestry in Queensland.

In commenting on factors underlying forest policy in Australia, Mr. Trist mentioned that, contrary to popular belief, the forest resources of this continent are very slender indeed. The natural forests are largely confined to the coastal area, and have suffered greatly during the course of agricultural development. They are being sadly overcut and no extensive area remains to be opened. Australia at present imports about one-third of its timber requirements and spends, *per capita*, almost as much as Great Britain on imported woods.

The average cut in Queensland in pre-war days was over 300 million super. feet per annum. Practically all soft and cabinet woods, except cypress pine, came from Crown lands, which means that private holdings are almost exhausted of their timbers; even with cypress and hardwoods, the private lands are not able to maintain their cuts and the proportion from Crown land is increasing every year. Mr. Trist pointed out that future timber production must come very largely from Crown lands and that a substantial proportion of private lands still cutting hardwoods should be acquired by the State.

The good quality of Australian timbers and the rapid rate of growth of Australian trees justify the development of forest supplies, even if the economic factor were not so pressing. However, the Forestry Department has not as yet a good deal of country to work upon. There are only three million acres of State forests, of which only one-half can be used for timber, the remainder being fringing forests or waste due to inaccessibility or use for firebreaks, watershed protection and erosion control. Acquisition of all lands which should be carrying forests rather than crops or pastures is a necessity and in addition the areas must be managed properly.

The forests of Queensland fall into three groups—(1) softwoods: hoop, bunya and kauri pines; (2) cypress pine and hardwoods; (3) cabinet and secondary woods.

(1) An estimated planting of 5,000 acres per year is required for the softwoods. To date 30,000 acres have been established, but the war has interfered with the programme and planting will have to be accelerated in the post-war years. The requirement for softwoods is 200,000 to 250,000 acres on a 40–50 year cutting-planting rotation, but even with exotic plantations this cannot be obtained on the present forestry reserves.

(2) The hardwood position can best be improved by acquiring private lands which have not been developed. Fortunately there is a growing realization that many alienated forest areas are unsuitable for farming or grazing and should go back to the Crown for forest purposes. Hardwoods are managed under a system of natural regeneration and at present 400,000 acres of hardwood and cypress pine are being given silvicultural treatment.

(3) The area of permanent reservation of cabinet wood forest is only 300,000 acres, but there are still substantial areas vacant. A survey is needed to ascertain whether these forests can be maintained permanently and what plantation work is required.

Mr. Trist concluded his address with some remarks on the farm wood-lot and emphasized the advantages of these plots.

## South Australian Branch.

At a special meeting held jointly with the Australian Association of Scientific Workers and the Institute of Engineers on 30th June, Dr. H. C. Coombs, Director-General, Ministry of Post-War Reconstruction, spoke on " Rural Reconstruction ".

In his address Dr. Coombs dealt with some of the major factors—economic, technical and social—which would need to be considered in placing Australian post-war agriculture on a sound and stable basis. He suggested that an international organization could be set up to stabilize export prices of major agricultural products. Such a body would hold buffer stocks which could be built up or released as required so that short- and long-term prices could be established with a minimum range of fluctuations. It would be necessary to make a readjustment of rural debts and some distinction should be made when credit is made available to the man on the land. Farmers who are in difficulties would need to be treated differently in this respect from the general or more normal cases. In the past, undue generosity had been shown in good times while insufficient finance had been available during depression periods. Speaking of overseas markets for our primary produce, Dr. Coombs emphasized that the maintenance of a high level of employment in the United States and Great Britain would readily solve the problem of finding markets for our produce. The difficulty of finding markets in the pre-war years was related to high unemployment ; it was not a question of an excessive production of foodstuffs.

Regarding soldier settlement after the war, the Rural Reconstruction Commission had already submitted a report on this subject. Settlements should be undertaken only when there were clear prospects of success. Care must be exercised in selecting settlers and the lack of capital should not be a bar to a man's eligibility. It had been found that a high percentage of servicemen have expressed the wish to go on the land after the war, so that it may be difficult to allow purely economic factors to operate by themselves. The Commission recommended that soldier settlement should be undertaken jointly by the Commonwealth and States.

Speaking on the technical efficiency of farming, the speaker stressed the need for making greater use of existing knowledge and it was very necessary that governments should foster the extension services in agriculture. While new technical devices were readily accepted (frequently passed on to the farmer by commercial firms), it was difficult to get the farmer to appreciate the value of more general or fundamental work, as for example, soil conservation. Government subsidies to primary industries should be regarded as temporary expedients while the farmer is improving his efficiency, and should be made for specific purposes to help him acquire that efficiency.

Finally, Dr. Coombs indicated how necessary it was to raise the general standard of living in the country to bridge the gap between country and city life, thus putting an end to the over-growth of our capital cities. In all this work, administration should be decentralized to local, cooperative and regional bodies.

The Branch has initiated a series of three discussions under the general title of " The Use of Land Resources ". The first was held at a meeting on 21st July, when three short papers were given. The subject was introduced by the President, who outlined the plan and scope of the meetings. The first was designed to provide a background to the later discussions and consisted of papers tracing development from the agricultural and land classification aspects from the foundation of the State to the present time. The second meeting would discuss the position rather as it is at present, also in three papers, the first from the producer's angle, the second dealing with the place of livestock in agriculture, and the third with soil conservation in relation to production. The third meeting of the series would more definitely face forward, concerning itself with the place of soil surveys, the investigation of soil fertility problems and various practical aspects in land development. The general plan is to bring before a wide circle of professional men the question of the proper use of land resources.

At the first of these meetings Mr. W. J. Spafford (Director of Agriculture) spoke on " Milestones and Lessons of the Past " ; Mr. J. N. McGilp (Chairman of Land Board) on " Development of South Australian Land Policies " ; and Mr. C. M. Hambidge (Surveyor-General) on " Subdivision and Valuation of Rural Land ".

## Tasmanian Branch.

A meeting of the Tasmanian Branch was held at Hobart on the 30th June, when discussions dealing with the technical activities of various sections of the Department of Agriculture were continued. The speaker for the evening was Mr. Raphael, who dealt mainly with the progress and development of the recently established experimental station at Summerleas. Originally designed as a quarantine centre and trial ground for berry fruits, this area had been switched over to vegetable seed production, plant breeding work and small scale trials.

## Victorian Branch.

On 29th June Mr. J. A. Aird, Past-President of the Branch, delivered his delayed presidential address, in which he discussed " Factors Affecting the Consumptive Use of Water ". (Consumptive use of water was defined as the quantity of water in acre-feet per acre per year, absorbed by plants and transpired or used directly in building plant tissue, together with that evaporated

from the land.) Lowry and Johnson, of the Bureau of Reclamation, U.S.A. (*Proc. Amer. Soc. Civil Engineers*, April, 1941) had shown that in some 20 irrigation districts and river catchments in U.S.A., there was a direct linear relationship between consumptive use of water in feet and " effective heat " (i.e., " the accumulation in day degrees of maximum daily temperatures above 32° F. during the growing season "). Lowry and Johnson's original graph and graphs of 11 river catchments and 10 irrigation districts in Victoria were displayed by the lecturer.

In the case of the river catchments, the average consumptive use over five years and the maximum consumptive use were plotted against the effective heat, and although the consumptive use tended to increase with the effective heat, the relationship was not as close as that found by Lowry and Johnson. In several instances, the mean of the average and the maximum fell on the line plotted by them. Werribee River showed greatest divergence. This was considered to be due to the fact that in summer part of the catchment became very dry, and the effective heat did not operate as there was no moisture available for evaporation and transpiration.

With the irrigation districts, there were only two (Shepparton and Tongala-Stanhope) in which the relationship between consumptive use and effective heat approached the agreement of that of Lowry and Johnson, although the average figures for all districts could be said to be in agreement with it. Taking each of the districts in turn, the nature of the plants grown was discussed, together with the effect they had on the quantity of water used and the period of irrigation. It was noticed that in all districts where the consumptive use was less than would be expected from the effective heat, there were large areas of annual pasture which were not growing during the period of greatest transpiration.

Other factors, besides heat, which would effect transpiration were also discussed. Of these, the chief was wind, which had a similar effect to what it had in evaporation. Its effect on this was shown by a comparison of temperature, humidity and wind at Walgett, N.S.W., and Walpeup, Vic. At Walgett the average temperature was 6° F. higher, the saturation deficit was of the order of 0·3 compared with 0·2 at Walpeup, but the annual evaporation was three inches less. This was attributed to wind, which had an average velocity of 8 miles an hour at Walpeup compared with 2·6 miles at Walgett.

In conclusion, Mr. Aird stated that it appeared from his investigations that the graph as drawn by Lowry and Johnson would be of use in the estimation of probable flow from river catchments for which rainfall and temperature records were known. For the estimation of water requirements for proposed irrigation districts, however, some adjustment would have to be made for the type of crops to be grown and possibly for the amount of wind.

Mr. F. W. Bulcock, Director-General of Agriculture, addressed members on 1st August on the Queensland Sugar Industry.

Members also attended the following meetings of the Melbourne University Agricultural Society. On 2nd June, Mr. F. Wilson, liaison officer between the C.S.I.R. and the Australian Wheat Board, spoke on " Preserving Wheat Stocks from the Ravages of Weevils ". He reviewed the position existing during the 1914–18 war and pointed out that authorities were quite unprepared for the problem which then arose. On this occasion, however, the Australian Wheat Board anticipated trouble by seeking the cooperation of the C.S.I.R. and others. Storage systems in various States, the different types of insects and infestations encountered and control methods adopted, were described. Losses had been comparatively small, stated Mr. Wilson, and cost of treatment was much lower than during the last war, even though there had to be some compromise between the views of the entomologist, the Government and the practical wheat storer.

On 14th July Mr. C. R. Lambert, Member of the Rural Reconstruction Commission, discussed " Some Aspects of Rural Reconstruction ".

## Western Australian Branch.

At a general meeting on 23rd June, Mr. W. P. Cass Smith, Plant Pathologist, Department of Agriculture, delivered his post-presidential address entitled " Some Aspects of Plant Pathology in Western Australia ", which is published among the articles in this issue of the Journal.

# Current Notes and News

## Seventh General Meeting.

The Seventh General Meeting of the Institute will be held in Melbourne in February, 1945. Whereas the fifth and sixth meetings were brief and were held for the transaction of purely formal business, it is intended that the forthcoming meeting should extend over three or four days and that, besides regular Institute business, technical discussions and symposia should be held. The detailed arrangements for the meeting, which are now under consideration, will be published in the December issue of this Journal.

## Application of Science to Australian Primary Industry

At a conference on the planning of science, initiated by the Victorian Division of the Australian Association of Scientific Workers and held in Melbourne in June, the first session was devoted to discussions under the above general title. The chairman was Professor S. M. Wadham and the speakers and their subjects were as follows :

C. T. Clark, Deputy Surveyor-General of Victoria : Stocktaking of Natural Resources.
G. W. Leeper, Senior Lecturer in Agricultural Chemistry, University of Melbourne : Co-operation between Scientists.
R. A. Boyle, President, Victorian Branch of Australian Institute of Agricultural Science : Extension of Scientific Knowledge among Primary Producers.
E. Munch-Petersen, Research Officer, Division of Animal Health, C.S.I.R. : Publication of Scientific Investigations.

Mr. C. T. Clark stated that one of the most urgent needs of Australia was the establishment of a Federal Directorate of Scientific Survey. Information of certain types was required by different departments or organizations, but not necessarily at the same time. Without some liaison between them, each had to collect and collate this data for its own needs. Such overlapping was a waste of time and money, as well as evidence of a disorderly approach to a national problem. There were numerous examples of difficulty in quickly obtaining reliable information on which to base projects of land utilization.

Mr. Clark urged a stocktaking of our natural resources. Development was limited by the nature and limit of these resources and until they were accurately assessed, orderly planning was impossible. All natural assets bore some relation to one another, to geological, climatic and topographical conditions and the economy of the whole community. But what was the exact nature of this relation ? The position in Victoria, stated the speaker, was that less than a quarter of the State was covered by standard topographical maps, about a tenth by detailed geological surveys, less than a quarter by air photography and less than a hundredth by intensive soil surveys. Only a small fraction of our forests had been scientifically assessed while there was no accurate knowledge of the quality and quantity of timber available.

Setting up a Federal Directorate of Scientific Survey (possibly within the Department of Post-War Reconstruction) was advocated. It should correlate surveys already carried out by State and Commonwealth authorities, and scientific institutions, and co-ordinate future activities. Perhaps the most urgent need was a series of reliably co-ordinated base maps. Their preparation could be greatly facilitated by assistance from the R.A.A.F. by air photography, the Australian Survey Corps and State and Federal Survey Departments in their respective areas. With this fundamental information, agricultural, regional or town planners could proceed with surety. There was also a great need for widening the scope of geological, soil, forest assessment, ecological and sociological surveys, for better gauging of rainfall, storm intensities and of stream flow.

Mr. G. W. Leeper said that scientific workers are nominally members of a world-wide cooperative undertaking, all helping in the progress of science by publishing their experiments and ideas. While ideally our careful system of abstracting should ensure that no contribution should be lost, in fact the system largely fails since so few workers really read the literature. (From his own surveys of references cited in original articles in agricultural chemistry Mr. Leeper said that he would put the proportion lower than one in ten.) Two measures might help to improve this situation : firstly, editors might encourage the writing of genuine review articles—which are rare today ; secondly, we might try to make examples of bad offenders by being outspokenly critical of those authors who fail to read the literature—especially of the multitude who read abstracts without consulting original articles.

However, whatever palliatives may be suggested, we must assume that communication by the printed word will remain fairly poor, and we should make the most of another means of spreading information—by meetings of people who work in the same fairly small field. It is essential for the field to be small. The peace-time meetings of the Association for the Advancement of Science cannot do what is needed, since so little time is available for any one subject that it is not worth while for the specialists to attend for the sake of that discussion alone. The

" School of Soil Science " held at the Waite Institute in 1939 achieved the end in mind, of allowing scientists from all over Australia to become familiar with one another's work, and incidentally of spreading the knowledge of overseas work with which individuals had come in contact.

Such meetings of one or two weeks, and also periodical visits to allied institutions for longer periods, are an essential part of a scientist's work ; this fact can hardly be contradicted, but its importance has not been sufficiently appreciated in Australia.

Speaking on the extension of scientific knowledge among primary producers, Mr. R. A. Boyle pointed out that the main handicaps up to the present were the lack of an entirely satisfactory link between the specialist and the practical agriculturalist, and the ability of the individual farmer to absorb and apply the available information. Establishment in Victoria of an effective farmer extension service was essential.

There should be a strong link between the scientist and the economist on the one hand, and the farmer on the other. Unfortunately there was an ever-widening gap between the extremes in both groups. An extension worker needed a grounding in a wide range of sciences and should be a specialist in some. While the best men probably would come from the combined environment of farm or agricultural college and the university, with greatest stress on the latter, it was essential that they should acquire the farmer's point of view. The district agricultural officer must be at home in the laboratory and on the research station, and be familiar with results from these institutions in relation to problems of farm management and finance. He should also act as a link between the farmer and the research institution, thus indicating practical problems for investigation.

Mr. Boyle suggested that a blend between war agricultural committees and agricultural bureaux would be an ideal organization to assist the district officer in connection with mass advice or instruction to farmers, demonstrations, audiences for specialist lecturers or the implementation of national projects. A skilfully directed extension service could exploit farmers' natural tendency to congregate. Suggested aids were (1) the encouragement of female interest in all topics, and extension specialists in farm home affairs, (2) daytime instruction, as far as possible, and (3) the combination of evening lectures with social entertainment.

Mr. E. Munch-Petersen stated that the number of publications containing results of scientific investigations is enormous, e.g. the British *World List of Periodicals*, published in 1933, contains about 33,000 entries, the U.S. *Union List*, of last year, between 115,000 and 120,000 entries. The editors of the first-named estimate that the annual increase of publications suited for inclusion is 1,000 to 1,200.

Abstracting journals, although exceedingly valuable, do not include every paper from all journals, even if only a special field of science is examined ; yet, there is a great deal of unnecessary overlapping. For example, all branches of chemistry are supposed to be covered by the American " Chemical Abstracts ", the " British Chemical and Physiological Abstracts " and the German " Chemisches Zentralblatt " ; each of these contains about 30,000 to 40,000 entries per annum, culled from between 3,500 to 4,000 various publications. Yet, although many published contributions are abstracted in all these, and may be other journals as well, some escape notice for one or more years, or even entirely, and this may happen to quite important papers. The cost of publication is very high, owing to relatively limited circulation.

The time spent in searching for specific information from so many different sources prevents the scientist from spending all his working hours on the job in hand. Furthermore, most of the scientists have to contribute at least part of their income to scientific societies, for many of which the only *raison-d'être* is their publications. Methods of publishing results and rationalizing distribution of information were examined by Bernal—among others—and put into effect by the American Documentation Institute in U.S.A.

Resolutions resulting from the session on primary industries were as follows :

1. That this Conference deplores the lack of plans for balanced land utilization in Australia and for the assessment of mineral resources and urges upon the Commonwealth and State Government the need for the extension and co-ordination of scientific work in connection with the characteristics and use of land—for example, surveys of Geology, Mineral Wealth, Soils, Meteorology, Stream Flow, Ecology, Forest Assessment, Rural Sociology.

It draws attention to the serious deficiency of co-ordinated topographical and cadastral maps upon which to record and correlate the results of such surveys.

The Conference asserts that scientists and those responsible for developmental works and conservation measures are greatly handicapped by this deficiency, and recommends that a directorate of scientific survey be set up in the Department of Reconstruction, its functions to include :

(*a*) The co-ordination of Commonwealth and State surveys in connection with the characteristics and use of land and the assessment of mineral resources.

(*b*) By the aid of a Committee of Scientists the determination of the order of priority in which further areas are to be surveyed, and the types of survey to be carried out therein.

(*c*) By the aid of the R.A.A.F. in air photography, the Australian Survey Corps in trigonometrical control and the State and Commonwealth Survey Departments in ground control, the provision of adequate co-ordinated cadastral and topographical base maps.

(*d*) Measures to ensure the scientific training and experience of sufficient personnel for the above work.

2. That the Victorian Government be urged to enable its Department of Agriculture to establish a Division of Extension Service, comprising a network of resident agricultural officers of wide and mature experience in interpreting the findings of research, in farm management and rural life generally and that these be suitably remunerated so as to attract agricultural science graduates of the necessary training and experience.

3. That the State embody the principles of War Agricultural Committees in a scheme to encourage

(*a*) group interest in extension service, and

(*b*) producer cooperation in the carrying out of any project concerned with the land which the State may decide to undertake on its own behalf or on behalf of the Federal Government.

It is suggested that resident district officers as advocated in the previous resolution would prove ideal links between the Department of Agriculture and these producer groups, whose continuity of existence and interest should be one of their prime responsibilities.

4. Regarding personal discussions between scientists as a most important means of improving their work and encouraging the standardization of techniques, this Conference recommends to all administrators of research organizations dealing with problems of primary production

(*a*) that research workers be given greater opportunities to meet other scientific workers for discussion of common problems, by means of travelling facilities and scholarships ;

(*b*) that within each laboratory, department or other research organization, regular conferences of scientific workers should be held. This is a matter of particular importance for scientific workers conducting research in the field ;

(*c*) that greater cooperation should be developed between different research organizations throughout Australia and New Zealand. Conferences of scientists in different laboratories or research institutes, and " refresher " schools of short duration should be held in order to facilitate such cooperation and increase the common knowledge of scientific workers.

## World Food Situation.

Dr. L. V. Burton, Editor of " Food Industries ", addressed the N.S.W. Branch of the Institute on 9th June, 1944, on the world food situation, with special reference to post-war Europe.

As a background the speaker outlined the events which led up to the crises in the agricultural economy of the United States in the thirties. He instanced the expansion of wheat acreage in the Soviet Union, the embargo on the import of dairy produce into Germany, and the expansion of pig production in Denmark. Dr. Burton emphasized the contention that the most important fixed point in economics was the capacity of the human stomach. In a normal year in the United States, this could be set at about 1,465 lb. of food per person.

The speaker then proceeded to a discussion of existing world food demands. For the purposes of this survey, he used a crude index representing the amount of food required to feed one man for one year. Dr. Burton stressed the seriousness of the food position in Russia, pointing out that climatic factors limited the food producing region of the Soviet Union to a triangle formed by lines joining Leningrad, Semipolatinsk and Odessa. Three-quarters of the population of Russia (estimated at 150–200 million people) lived within this area. At one stage 25 per cent. of the triangle was occupied by the German army. Taking all factors into consideration, the speaker estimated that food for 50 million people in Russia would be required for external sources for at least one year after the war.

It has been estimated by competent authorities that England was at present producing 70 per cent. of her food requirements. With a population of 45 million people, this virtually meant that approximately 12 million people had to be fed from elsewhere. Estimates for the " food demand " of Persia and North Africa were placed at eight million and five million people respectively. Estimates in respect of Asiatic countries, particularly India and China, were difficult to arrive at. To feed the population of these countries adequately in normal times was a major job itself.

Dr. Burton then briefly discussed the question of the capacity of other countries to produce surplus food for export. United States, with a population of 137 million, was normally a food-importing country in the aggregate. With imposition of very severe rationing, she might produce a surplus sufficient to feed 15 million. Canada, with a population of 11 million, might feed five million in addition. Other food-exporting countries, including Australia, New Zealand, Argentina, etc., might supply food for an additional 23 million. Thus, on the basis of these estimates, there was a prospective supply of 43 million units to meet a population demand in Russia and Great Britain alone of 62 million.

The task of feeding liberated Europe was then discussed. Before the war 10 per cent. of Europe's food was imported. Estimates made by the British Ministry of Food of the position after German occupation showed that the average person in Britain was receiving 2,800 calories per day, and in Germany 2,800–3,000 calories. Non-Jewish Poles received 800 calories per day and Jewish Poles 400 calories per day. The average for all Europe was set at 1,600 calories per man per day. This figure should be compared with the basal diet of 1,800 calories per man per day and a pre-war European average of 2,900 calories.

The United Nations Relief and Rehabilitation Administration (U.N.R.R.A.), in facing its task of feeding post-war Europe, had set as its prime objective the addition of 400 calories per day to the average of 1,600 calories per man per day. This alone requires the supply of 10 million tons of food a year, of which U.N.R.R.A. could barely find 50 per cent. The European governments in exile maintain that nothing short of the addition of 1,000 calories per day to the existing diet is satisfactory. This would represent 25 million tons of food per annum. The largest problem U.N.R.R.A. will have to meet is that of distribution rather than of production. Ability to supply consumer goods to liberated populations was essential. U.N.R.R.A. stressed the rehabilitation rather than the relief part of its task.

The production of European agriculture has been diminished by the war, and it will diminish substantially more when the Germans apply a "scorched earth" policy on their retreat. Fertiliser shortage (partly the result of the cutting off of the supply of four million tons per annum of phosphate from North Africa) is said to have been responsible for 5–10 per cent. decline in crop yields. It is estimated that in Germany the pig population has been reduced by 33 per cent. and the cattle population by 10 per cent. Comparable figures are 33 per cent. and 10 per cent. for Denmark and 50 per cent. and 10 per cent. for Belgium.

The farm machinery situation in Europe might be met, to some extent, by the use of salvaged military trucks, but it is imperative that agricultural implement factories be turned over to this type of production as early as possible. A stock-pile of vegetable seeds amounting to half of the United States' 1942 production would be required. Even now, seed production is strained to the limit. It is proposed that there be no shipments of dairy cattle to Europe, but rather that depleted herds there at present should be built up. It was an important principle of U.N.R.R.A.'s policy that the crop pattern (and hence the diet) imposed by the Nazis must be maintained during the rehabilitation period. The Nazi food production plant must be recognized as highly successful, and if continued, it would enable four-fifths to seven-eighths of Europe's food requirements to be produced at home for two to three years after Germany is defeated. Notwithstanding this plan, the supply of even the remaining eighth of the food requirements from external sources represents a colossal task. Feeding the population will probably be easier in the first year than in the second owing to the existence of stock-piles for military purposes.

The most difficult foods to supply for European relief will be edible fats and oils. It is proposed that of the estimated meat requirements of 600,000 tons United States and Argentine should provide 50 per cent. each, and United States should provide all the milk requirements in the first year. It is also estimated that Europe will require five million tons of wheat (i.e., 170 million bushels), Canada, United States and Argentine to be the suppliers. The United States wheat stock position is deteriorating due to use of wheat for feeding stock and industrial purposes, and Canada has experienced, and is likely to continue to experience, transport difficulties with this grain. Hence the wheat situation is not very bright if present trends continue. Four hundred thousand tons of sugar will be required, of which there is no known potential source at present.

All this presupposes a continuance of the *status quo* in the United States. That country has been particularly fortunate in having experienced seven good seasons in the last seven years. If a drought were experienced in the current season there may be particularly serious consequences.

Dr. Burton concluded his address with some observations on the possible duration of the present food crisis. It was his considered opinion that, assuming no major setbacks, we could not hope for any substantial improvement in the situation before three years after the cessation of hostilities.

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## Erratum.

Vol. 10, No. 2, June, 1944, eighth line from bottom of page 87. For "ensuing", *read* "previous".

# Book Review

**A SOURCE BOOK OF AGRICULTURAL CHEMISTRY, by C. A. Browne.**

(*Chronica Botanica, Waltham, Mass., U.S.A., and Angus and Robertson, Sydney, N.S.W.*, 290 *pages.* 1943. *Price* $5.00.)

The wide field covered by agricultural chemistry makes this volume a history, not merely of agricultural chemistry, but almost of science itself.

The author commences, somewhat unusually, by considering the definition of Agricultural Chemistry, quoting the words of Mayer that " . . . the complex phenomena of agriculture permits no pedantic separation of the individual sciences that are mutually concerned therewith . . . The established term Agricultural Chemistry indicates that of the various other related sciences chemistry was the first to have a voice in considering the basic principles of agriculture . . . We could just as well speak of Agricultural Physics or of Minerology or of Plant Physiology in the service of agriculture. But following the precedent of others, as well as for the sake of simplicity, I prefer to call the sum total of these different scientific approaches to husbandry Agricultural Chemistry."

With this introduction, the reader might expect a rather wider consideration of the part played by these sciences in the development of agricultural chemistry, but that is largely precluded by the termination of the book with the end of Liebig's work at Giessen.

Dr. Browne has done a great service by drawing together extracts from the works of scientists and philosophers of two thousand years of European civilization, and by using the direct translation has allowed them on all critical issues to speak for themselves. At the same time he has interpreted sympathetically but quite objectively, some of the phrases in more modern terms ; in a manner which emphasizes the difficulties under which the earlier investigators worked owing to the lack of established terminology.

It is difficult to select any part of the book for particular comment, but it is at least justifiable to say that the book shows most clearly the strength and the weakness of Liebig—his strength in the clarity of his reasoning, and his weakness in his attempt to claim the credit for what others had done. In the accounts it is clear that Liebig was just one of many, some of whom preceded him by many years, whose work lead to the general acceptance of the theory of mineral nutrition of plants. The accounts of some of the earlier demonstrations are very attractive—particularly the one of Wiegman's in which plants were grown in a platinum vessel, on fine platinum wire moistened with distilled water.

In conclusion, we can say that this book is one which should be read by the agricultural chemist, and could be read with profit by most workers in agriculture.

E. G. Hallsworth.

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# Obituary

## CLARENCE PARSONS GLASSCOCK.

When Wing Commander C. P. Glasscock, B.Sc.Agr., was reported missing in air operations in October, 1943, his many friends hoped that he might have survived and reached a place of safety, but unfortunately in a recent casualty list he has been reported " Killed in Air Operations ". The son of a naval officer, he entered the Faculty of Agriculture in 1931 and graduated in 1936.

Soon afterwards he was appointed to a position in the Agrostologist's Branch of the New South Wales Department of Agriculture and showed promise of a successful career in this important branch of agricultural science. He was always keenly interested in aviation, and before war broke out had passed with credit through an aviation school at Richmond and obtained his pilot's certificate. Almost immediately on the declaration of war he volunteered for the Air Force, in which he held many important positions and made such rapid progress that it was difficult to follow his movements. At first he was engaged in instructional work, which he carried out very successfully, but he longed for more active participation in the struggle, and we next heard of him as Squadron Leader at Darwin. He was later brought back to Head Office in Melbourne on account of the knowledge he had acquired, but in 1943 he was sent up north with the rank of Wing Commander, and one gathered that he inspired great confidence in his officers and men. In the actual operation in which he lost his life he need not have been in the air at all, but he preferred to share all the risks with his " boys " and unfortunately paid the full penalty.

Clarrie had a very winsome personality and was very popular with his fellow students, members of the staff and his associates in the Department of Agriculture.

Our deepest sympathy is extended to all his relatives and intimate friends.

## ALEXANDER McTAGGART.

On 16th May the death occurred in Sydney, following a short illness, of Dr. A. McTaggart, Principal Plant Introduction Officer in the Division of Plant Industry, Council for Scientific and Industrial Research.

Born in New Zealand in 1883, the late Dr. McTaggart spent some years in the Department of Agriculture there before proceeding to the Ontario Agricultural College, Guelph, Canada, where he took his Bachelor of Science degree in 1912. This was followed by an M.Sc. (Agric.) degree at Cornell University in 1913, after which he returned to New Zealand, and held the position of agriculturist in the Dominion Department of Agriculture until 1919. He returned to Cornell University and gained the Ph.D. in 1921. After teaching soil technology and carrying out soil surveys there for some time, he was appointed Assistant Professor of Agronomy at Macdonald College of McGill University, a position which he held until joining the C.S.I.R.

Appointed in 1929 to organize and take charge of plant introduction work in the newly-established Division of Plant Industry, Dr. McTaggart brought with him a wide and varied background of knowledge on plant problems. During his fourteen years, he was responsible for introducing and testing more than 8,000 varieties of economic plants from all parts of the world, many of which have proved of value in peace or in war. Results with these plants have been reported in several contributions in the C.S.I.R. Journal and in C.S.I.R. Pamphlet No. 114, while another line of work was reflected in the preparation of C.S.I.R. Bulletin No. 99 : " A Survey of the Pastures of Australia ".

He was a member of the Canadian Society of Technical Agriculturalists from its inception and published in the Society's journal on " War-Time Agriculture in Australia " in 1941.

A foundation member of the Australian Institute of Agricultural Science, he was a regular attendant at the A.C.T. Branch meetings. He was a member of the Branch Sub-Committee on Plant Quarantine and materially assisted in the preparation of the report which was adopted in September, 1938. In that year he published in this journal an article on " Some Principles Affecting the Introduction of Plants ".

Dr. McTaggart was liked and respected by those who knew him for his qualities of sterling integrity. His personal qualities found expression in visiting the sick in hospital, in devotion to the Presbyterian Church and its work and in Freemasonry in Canberra. His death at the early age of 61 removed one of the foundation members of the Division of Plant Industry, and one whose loss will be greatly felt. The sympathy of the Institute is extended to his widow.

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# Personal Notes

Recent releases to the N.S.W. Department of Agriculture from the Army include Messrs. C. R. Wallace and R. D. Wilson, who have resumed entomological and plant pathological work respectively and are located at Head Office, Sydney.

Mr. T. T. Colquhoun has returned to Adelaide, where he has been appointed Assistant Deputy Director of Manpower for the Department of War Organization of Industry.

Mr. G. D. Hubble, of the Soils Division of C.S.I.R., has recently been transferred from Adelaide to Tasmania as regional soil surveyor, and is located at Hobart.

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